Therefore only through education does one come to be dissatisfied with his own knowledge, and only through teaching others does one come to realize the uncomfortable inadequacy of his knowledge. Being dissatisfied with his own knowledge, one then realizes that the trouble lies with himself, and realizing the uncomfortable inadequacy of his knowledge, one then feels stimulated to improve himself. Therefore it is said, "The processes of teaching and learning stimulate one another."—CONFUCIUS

CONTENTS FOR MAY, 1943

Why Laboratory Science?—*Traver C. Sutton* 401

General Science in the Panama Canal Zone—*W. Hugh Stickler and Raymond L. Walter* 405

Some Techniques in the Teaching of Conservation—*Charlotte L. Grant* 418

Photographic Aids to Teaching. III. An Apparatus for Making Film Strips and 2×2 Slides—*Charles Tanzer* 423

An Improved Electrolysis Apparatus—*W. A. Porter* 426

Per Cent Without Three Cases—*Ernest N. Brown* 428

The Contribution of Science in the Development of Art. Part I.—*A. Reid Winsey and Lester B. Sands* 431

Notes on Vacuum Tube Electroscope—*Arthur B. Hussey* 437

Improving Primary Grade Science by Problem Teaching—*Charlotte V. Junge* 438

A Comparative Performance of High School and University Freshmen on a Test of Biological Misconceptions—*Melvin W. Barnes and Gilbert W. Mouser* 447

Science Equipment—"For Rent"—*Shailer Peterson* 451

Notes from a Mathematics Classroom—*Joseph A. Nyberg* 455

The Forms and Uses of Graphite—*Bernard H. Porter* 459

An Analysis of a Purported Trisection of an Angle with Ruler and Compasses—*H. C. Schepler* 465

The Selection of Books in the Field of Mathematics—*Manning M. Pattillo, Jr.* 468

Science and the Victory Corps Program in Boulder High School—*G. D. McGrath* 475

Science Activity Stimulates Interest—*John J. Cochrane* 478

Problem Department—*G. H. Jamison* 479

Science Questions—*Franklin T. Jones* 484

Books and Pamphlets Received 488

Book Reviews 489

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WHY LABORATORY SCIENCE?

TRAVER C. SUTTON
Cass Technical High School, Detroit, Michigan

I am always finding people who have as an object in life the vitalizing of our high school science teaching methods. They want the secondary school science methods drastically and dramatically revised. Without doubt there is much room for improvement in high school science methods everywhere in the country. Any method of better preparing young people for life in a democracy is highly important, and should be encouraged. How much value, and how much good new methods will do, depends largely upon the practical experience, judgment and intelligence of those who are directing the use of the methods, and to the extent that the methods are practical. There is always a real need for protecting fundamentals against enthusiastic faddish ideas and so-called new methods.

We live in a democracy. We believe in democracy. There is nothing very mysterious and difficult about a sound method to prepare young people to live successfully in a democracy. It is the job of education to prepare boys and girls to live in and be a part of democracy.

Young people need to be taught correct scientific principles and patriotism at home and by their teachers. The best way to teach scientific principles is through practical first-hand participation and experience; patriotism can best be taught through participation and example.

In the teaching of the sciences regular teachers of intelligence and high standards are infinitely more valuable than highly paid specialists, who have never taught high school students,

and whose chief stock in trade are new methods and substitute courses. Beware of substitute courses. There has been in the past a too ready acceptance of untried methods having for their only recommendation the fluent tongues of ambitious specialists.

Boys and girls need to be grounded in fundamentals and practice—and in no other field do we need so much care and emphasis in teaching fundamentals and experience in practice as in science. This work of teaching fundamentals and practice takes time and is hard work. Beware of the superimposed short course—for there are no true short cuts if a good and honest job is to be done.

There is more and more expression of opinion and belief by the older, wiser and more experienced teachers who come daily into contact with high school pupils that real vitalization of science teaching methods must come through practical participation in the work rather than in the process of having the students as an audience and having the audience watching the teacher.

One day not so long ago I had a very interesting conversation with a very wise old teacher who said to me, "I am a very devoted baseball fan. I have carefully studied baseball strategy and know all the fine points of the grand old American game. When Charlie Gehringer was in his prime I was able from the grandstand to tell him about his good plays, and I felt well qualified to give him some good pointers about how to avoid making bad plays. For many years I have watched and studied the manner in which baseball players demonstrate their baseball ability. I know baseball. In fact I could write a perfect examination on baseball—rules and playing and management." Then this old and wise teacher leaned back in his chair and continued, "In spite of my baseball knowledge and my years of watching baseball demonstrations no big league baseball manager has as yet offered me a contract to become a playing member of his team. When I consider the vast sum of baseball information I have accumulated, and the knowledge of the game I have acquired plus the technique I have developed in watching baseball demonstrations I am a little disappointed to find big league baseball managers so lacking in appreciation and true judgment."

Our conversation continued with, "I wish I were as sure of any one thing as the majority of our reformers of science teaching are of everything,"—and then after a pause, "What were

you saying about substituting science demonstrations for individual laboratory work?"

Last week I had dinner with the manager and owner of a small but good manufacturing plant. This man employs a relatively large number of young men who must possess good basic science training. Our subject of conversation was naturally about high school science teaching, and the manner in which industry judged the results of such science teaching. Allow me to pass on to you his observations. Here they are: "You high school teachers give to us plenty of high school graduates who *can talk all of the answers* but they cannot actually use their hands and heads in getting the job done. There is a definite need for the practical application of the technical and scientific information to the job. We have checked with our workers and found that those having plenty of shop and individual laboratory experience are the ones who really deliver the goods."

The writer of this article has always assumed that the real justification for teaching a particular science was to be found in the uses made of the science. The method selected for the teaching should be solely in the terms of the use objectives to which it is intended to insure. With this thought in mind, and still not convinced that the demonstration might not be of value as a substitute for some of the individual laboratory work I made it a point to consult with a man who has taught in the secondary school science field for at least thirty years. In order to start the argument I remarked that students having the opportunity of observing demonstration science experiments, carried out under competent teachers, seem to be able to obtain a very good understanding of the subject. I pointed out that when mastery tests were given that these students were able to pass the test with very high grades. In fact they did as well on the tests as did those students who gained their information through the use of the traditional laboratory methods. My colleague agreed with the statement I had made. Then he observed, "I have used the demonstration method and given mastery tests, and I have found that my students obtained excellent marks. However when these boys who have observed and apparently thoroughly understood the science demonstrations are placed on jobs outside the school they fail. While on the other hand the youngsters who did not receive as high grades on the mastery tests but who had had the opportunity to handle and to work

with actual apparatus in the laboratory were able to succeed on the same type of job."

Would dropping the emphasis on the individual laboratory method, which when properly directed seems to be the best means of developing the reasoning powers of our high school pupils, aid our boys and girls to use their heads for something more than storehouses for the accumulation of facts? There is a feeling that the attempts to get away from tried and proved fundamentals are merely alibis of a teaching generation which may have betrayed its students by not insisting upon a firm grounding in those essentials which can be gained only through student participating experiences. The feeling has often been expressed since the outbreak of the present war that many of our students are being made remarkable "smatterers in science," and that some of the reforms in teaching are leaving them far less truly educated than their parents and grandparents are, or were.

The question of substituting demonstration work for individual laboratory work is important. Some of our teachers feel that for the time being the less said the better, and perhaps they are right. I do not wish to appear to be the person who is ready to rock the boat, but if our method of presenting the sciences is not correct then let us find out what the correct method is. Experience seems to indicate that the demonstration experiment should never be substituted for individual laboratory work. Apparently it should be used to supplement and to prepare the student for the so-called traditional individual laboratory work. Whether our readers agree or disagree is less important than the fact that it may stimulate others to do some constructive thinking and acting in this important matter.

We are truly interested in the teaching of the sciences, and it is well to remember that training which will enable the student to meet in a successful manner real situations and problems is much to be desired. We must remember that experience is the best teacher. Which is the better way of gaining this required experience, through watching a teacher give a carefully worked out demonstration or through having the student perform the experiment as an individual job?

Education can only at its peril detach itself from the economic processes and what is happening in the world.—*John Grierson, Canadian National Film Commissioner.*

GENERAL SCIENCE IN THE PANAMA CANAL ZONE

W. Hugh Stickler and Raymond L. Walter
Division of Schools, The Panama Canal, Canal Zone

For a number of years previous to the present semester the authors taught courses in General Science in the Canal Zone Division of Schools. Soon after their arrival on the Isthmus it became obvious to them that if science were to be meaningful in the lives of their students the course would necessarily have to be very different from that taught in the United States proper. To be successful any high school general science course must make use of the scientific materials at hand. Since the scientific materials of the Canal Zone and adjoining Panama are located in an environmental setting quite different from any in the United States, the course must be modified accordingly. Publications, including textbooks, and other science teaching materials prepared for States' consumption are often unsuitable for tropical Panama. Yet, when the necessary changes are made and the course is augmented by suitable supplementary teaching materials, this environment offers an unusually fine opportunity for the first hand study of general science in a program of general education.

It is not the intention of the writers to tell general science teachers what they shall teach or how they shall teach. We do wish, however, to record some of the ways in which we have modified our course in order that the scientific aspects of the local environment may be used to meet certain of the needs of students in this community. It is hoped that these modifications may be suggestive to teachers in other communities.

A brief consideration of the background for a program of general science in this setting is in order. The Canal Zone is a narrow strip of land approximately 50 miles long and 10 miles wide extending across the Isthmus of Panama at one of its narrowest points. The latitude is approximately 9° North, the longitude about 79° West. Historically this is one of the oldest regions in the Western Hemisphere. Columbus, Pizarro, Balboa, Cortez, Drake, Morgan and others less notable were all familiar with these shores. Within ten miles of the two high schools are mountains, savannas, swamps, jungles, freshwater streams and lakes, coral reefs, islands and open ocean. The Panama Canal itself represents one of man's greatest achievements in applied science.

People from all parts of the world are gathered about this famous waterway, making it one of the most cosmopolitan places on earth. White secondary school students are the children of Panama Canal or Panama Railroad employees, tuition pupils from adjoining Panama, or children of men in the armed forces of the United States. Since the outbreak of the war there have been very few of the latter. Canal Zone pupils come from all parts of the United States as well as from numerous foreign countries. In general, they have considerably higher than usual ability. They achieve well academically as verified by standardized tests and subsequent college work. A relatively high degree of economic homogeneity prevails in the homes from which these students come. There is almost no poverty, neither is there great wealth. In recent years between 60% and 75% of our graduates have gone on to college. Still others have continued in the local apprenticeship-learnership school. Formal education is usually augmented by wide travel and other experiences which ordinarily do not characterize high school pupils in the United States.

The Canal Zone is an interesting place in which to study general science. Conditions are enviable for the scientist inasmuch as we live in the midst of a veritable scientific laboratory. An extremely wide variety of scientific principles is illustrated or applied here. Probably no place of equal size in the world better shows the effects of the applications of the methods of science. Through science this environment has been changed from one of mud, swamp, filth, tropical fevers and diseases, heat and multitudinous insects into a state of comfort and health which forty years ago seemed impossible. Here is to be found a six-inch refracting telescope which operates under the Division of Schools. Many excellent cameras are owned by local pupils. The Section of Surveys maintains a Hydrographic and Meteorological Office at both Cristobal and Balboa. The Balboa office also has charge of the Canal Zone seismograph. All are available for school work. The Health Department is available for the consideration of health problems not pertinent in temperate zones. Tuberculosis, pneumonia, hookworm, malaria, dysentery, fungus and other tropical diseases are still with us, and nutrition in these latitudes presents new problems. Because of its convenience and low cost, electrical power finds particularly wide usage in the Canal Zone. Many interesting geological phenomena are close at hand. For instance, Cristobal stands on what

was formerly a coral island. Gaillard Cut on the canal is still unstable because of rock slides. Within a quarter of a mile of the Balboa High School building are two sizable volcanic hills which are composed of entirely different igneous materials. The science involved in the construction and operation of the Panama Canal itself is not to be forgotten in our general science work here. At present a third set of locks is under construction, and the war has brought with it numerous defense projects. Acre for acre there is probably not a more significant spot of land in the Western Hemisphere today than the Canal Zone.

In addition to all of the scientific materials just mentioned, Canal Zone students have the advantage of having close at hand a very large proportion of the mechanical contrivances which science has devised. Dredges, huge cranes, pile drivers, automobiles, tractors, trains, ships, submarines, aircraft carriers, battleships, telephones, radios, range finders, huge guns, filtration plants, hydroelectric plants and all types of airplanes are all within the common experience of our students.

A most interesting tropical living environment is available for study at all times during the year. The local flora and fauna are almost completely different from those ordinarily encountered in the United States. A wide variety of habitats exists. Fresh and salt water creatures are abundant and diversified. Nearby coral reefs are veritable wonderlands for those interested in living things. Intricate life relationships and a wide variety of special adaptations are to be found in these latitudes. Because of the high temperatures and humidities the problems of home maintenance in the tropics are accentuated. The Canal Zone Experimental Gardens have imported tropical and sub-tropical plants from all over the world. Many trees, shrubs and flowers from such places as Madagascar, the Fiji Islands, India, the Philippines, China and other far away lands may be seen growing about Canal Zone homes. The natural jungle environment at Barro Colorado Island in Gatun Lake has been left unmolested, and the Institute for Research in Tropical America maintains a station here for research in tropical biology. Zoos in which may be found small but good collections of tropical animals are accessible. Here tropical animals may be observed and studied without inconvenience. Pupils have a right to understand these multitudinous phases of their Canal Zone environment. It is within the realm of science to help them to this understanding.

Truthfully it can be said that few places afford such a splendid opportunity for the study of general science as does the Canal Zone.

The authors are committed to the philosophy that education involves the whole child. To understand an individual apart from the environment in which he lives is nonsensical for the environment is inextricably interwoven into the life of the child, both in his present capacity as a child and in his future life as a citizen in the school and the community. Since the interpretation of the physical and biological environments, together with at least a partial interpretation of their impact upon the social affairs of men, lies within the realm of science and is attained through reasoning in the scientific method, one finds here a sound philosophical foundation upon which to build a science program. Working in such an educational philosophy science must be cognizant of the social phases of living. In such a course general science materials must be integrated with the materials of local history, geography, health education, ethnology, civics and the other social sciences. This is precisely what we propose to do: to help the pupil interpret the environment of the Isthmus of Panama, an environment much different from any in the whole of the United States, in relation to its long history, its interesting geography, its present importance, its health problems and various other social considerations. It becomes obvious, therefore, that in comparison with general science programs offered in the United States, a course suitable for the Canal Zone becomes distinctly different and unique.

With this brief description of the physical and biological environments in mind and working under the philosophy advanced above, let us note some of the ways in which general science materials of the local environment can be adapted for local pupil consumption. First, let us consider the modifications deemed worthwhile in astronomy, or the problems of the earth in relation to the rest of the universe as viewed from 9° North Latitude, 79° West Longitude. The tropical sky appears different from the sky as seen in the temperate zone. Polaris is 9° or 10° above the horizon instead of 30° or 40°. Here Ursa Major constellation is not visible on all clear nights throughout the year as it may dip below the horizon. The Southern Cross and other constellations of the Southern Hemisphere are clearly observable and must not be omitted from discussion. Normally thousands of ships pass through the Panama Canal in a year's time.

Also nearly all of our students have made ocean trips. Hence, we feel obligated to point out a few of the navigation landmarks and include a brief discussion of navigation procedures. At this latitude the earth is spinning on its axis at a velocity of something like 1000 miles per hour, thus causing short dawns and twilights. Also, because of its proximity to the equator, the Isthmus shows but little variation in the length of day and night at various seasons throughout the year. It has not been deemed necessary to institute the War Time program in the Canal Zone. We still operate on Eastern Standard Time. During the year the sun shifts both to the north and to the south of the observer. In recent years sun spots have repeatedly disrupted communications about the Isthmus. From their classroom windows students in Cristobal High School see the tides ebb and flow daily. It is well, however, to explain to Canal Zone pupils why Caribbean tides at Cristobal are only one or two feet high while the Pacific tides at Balboa vary from fifteen to more than twenty feet. Finally, tidal action in the atmosphere is clearly registered on Canal Zone barographs. These are to point out but a few modifications in content which we feel must be made in a single unit of work.

United States textbooks are thoroughly inadequate for the local situation in their discussions of weather and climate. Canal Zone climate is distinctly tropical. Here the prevailing winds are the northeast trades, not the westerlies, and doldrums alternate with the trades giving wet and dry seasons, not hot and cold. Panama is south of the "hurricane belt" although Panama-bound ships en route from the States often encounter them. The barometer is ordinarily so steady that highs and lows are not readily discernible. Temperatures are so uniform as to be monotonous. The January average daily maximum is 85.0°F. In June the average daily maximum is only 85.6°F. The diurnal range averages 9°F. at Cristobal and 14°F. at Balboa. Never in the history of the weather records has the Isthmus experienced an official temperature of 100°F. The record high is 98°F., the record low 59°F., thus giving an extreme range of only 39°F. By way of comparison, certain midwestern and plains states' communities have recorded changes of 50° to 70° or more in a single day. The weather here is so uniform that even in peace times the radio stations and newspapers do not bother to give weather forecasts. Once during a tropical downpour, on December 1, 1932, small fishes actually rained from the sky at Cristobal. The

event is recorded in the September, 1933 issue of *Natural History* magazine by Kenneth W. Vinton, local science instructor. Isthmian mountains cause a turbulence in the air over them which makes for rough flying. They also greatly affect rainfall. Porto Bello on the north coast averages 180 inches of rainfall annually; Cristobal also on the Caribbean averages 128 inches; and Balboa on the leeward Pacific side averages only 68 inches; yet all three townsites are within 60 miles of each other. A study of the coastline, geography, topography, high relative humidities (75% to 95% or more), and the prevailing winds of the Isthmus affords a ready explanation. It might be pointed out that this varying rainfall affects the vegetation on the two sides of the Isthmus. Toward Costa Rica the higher mountains cut off so much of the rain as to cause the leeward Pacific side to be relatively dry pasture land. Toward Colombia, South America, lower mountains permit much greater quantities of water to pass over before condensation, thus forming the impenetrable jungles of the Darien Indian country. While not strictly pertaining to climate and weather, it might be said that Admiral Peary's north polar exploration ship, the *Roosevelt*, lies hard aground in the Old French Canal at Cristobal where it is accessible for observation. Also it might be added that Admiral Byrd's south polar exploration ships have come through the canal on several occasions. On the last trip north of the *North Star* our science people went aboard while she lay docked at Balboa and listened for over an hour to the third officer talk informally, answer our questions, and explain photographs taken during the expedition.

Although recent (Cenozoic), geologically speaking, the Isthmus shows many interesting geological features. The soil in general is poor about the Canal Zone. It contains considerable quantities of iron as is evidenced by its red color. Although formed by small marine animals, coral formations have geological significance. Reefs skirt long distances of the Caribbean coast, and the San Blas Islands, down Colombia way and numbering 300 or 400, are entirely of coral origin. Certain Panamanian peaks rise to more than 11,000 feet. However, the Panama Canal runs through an area where the mountains dip to one of the lowest passes in their entire length from Alaska to the Tierro del Fuego. Also the Isthmus shrinks to its narrowest width in this region. Most of the geological formations are sedimentary and consist of clays, shales, tuffs, and limestones. The numerous and costly slides at Gaillard (Culebra) Cut bear consideration. The

construction problems at Madden Dam were accentuated on account of the honeycombed limestone in the region. Volcanic activity is in evidence. Intrusions are common. Note has already been made of two volcanic hills at the Pacific terminal of the canal. Although only a few hundred yards apart Ancon Hill is made of rhyolite while Sosa Hill is composed of basalt. Both of these materials have been or are being used in the construction of the canal and/or defense projects. Incidentally, Sosa Hill, less than a quarter of a mile from Balboa High School, affords an excellent example of a large fault. Other evidences of diastrophism are numerous. Mollusc fossils may be seen in road cuts and in the third locks' excavation, and at Toro Point deposits of coquina may be found at elevations of 200–300 feet. Earth tremors occur frequently on the Isthmus and are recorded on the local seismograph. While numerous, earthquakes are seldom severe. Isthmian rocks are so soft and weak that stresses and strains are adjusted frequently but without violence. Certain geological products are produced commercially. The Republic of Panama has much gold, a fact which has played an important part in the history of this region. The amount of gold which passed over the Las Cruces Trail from Peru and Central America, including Panama, must have been enormous. Manganese has been mined at times in the region of Nombre de Dios, named by Columbus and supposedly the oldest European settlement on the mainland still in existence. Although there is some oil seepage along certain rivers, no petroleum is produced commercially. Neither are there coal deposits of commercial value. Tremendous quantities of earth materials have been and are being used in the construction, maintenance and defense of the Panama Canal and the third set of locks. It is interesting to teach earth science here.

Little deviation is made from the usual methods in teaching water in relation to life, except to point out that Isthmian dwellers must ever be on guard against such water-borne diseases as typhoid and dysentery. No raw surface water is safe for human consumption in this region. This fact logically leads to a consideration of our local water supply which is considered to be one of the finest in the tropics if not in the entire world. Field trip studies are made of the filtration plant at either Mt. Hope or Miraflores where the entire process of water treatment is explained by the chemist in charge. Finally, it is pointed out that the local water supply has an international significance inasmuch as Ca-

nal Zone water is piped to the two leading Panamanian cities of Colon and Panama City and sent to all corners of the earth by ships at sea.

Man's control of the energy resources of the world comes in for considerable discussion because of the extremely wide variety of applications of machines and power tools in the Canal Zone, mention of which has been made in an earlier paragraph. It might be pointed out that the world's largest coaling station is located at Cristobal. Large amounts of gasoline are used, and a classroom explanation is in order for the fact that at the time of this writing gasoline in the Canal Zone costs $11\frac{1}{2}$¢ per gallon while the same gasoline in a pump across the street in the Republic of Panama costs 30¢ or more. Electricity finds an exceptionally wide range of applications here. In peace times each of the three Canal Zone generating plants, two hydroelectric and one Diesel, is available for study. Here again an economic problem may be considered. Canal Zone current is developed chiefly from water and sells at a beginning rate of 2¢ per KWH while in the Republic of Panama power is developed from fuel oil and sells at a beginning rate of 14¢ per KWH. Because of the high humidities here it is necessary to have electric heating units in all dry closets. Also because of the high humidities it might be mentioned that it is very difficult if not impossible to perform experiments or demonstrations with static electricity inasmuch as the static charge dissipates very rapidly in the moist air. In the homes of all Panama Canal and Panama Railroad employees electrical power is used for cooking and water heating. Much use is made of electrical energy in communication. Telegraphs, cables, long-and-short wave radios, and transoceanic telephony are common in the experience of local pupils. Many have talked long-distance to the United States.

Perhaps the greatest adjustments of all must be made in the unit dealing with living things. Life here is abundant, varied and tropical. Biological pressures are in evidence at all times. It is educational foolishness to discuss oaks, maples and corn when our plant examples consist of mahoganies, orchids, mangroves, palms and sugar cane or to discuss rabbits, garter snakes, honeybees and sparrows when our animals are armadillos, ant eaters, sloths, capybaras, ocelots, tapirs, coatis, monkeys, iguanas, fer-de-lances, bushmasters, boa constrictors, tarantulas, termites, leaf-cutter ants, turkey buzzards, parrots and toucans. An extremely wide variety of life relationships and

habitats abound here within very short distances from the high schools. These are available for study at all times during the year. For instance, less than fifty yards from the general science classroom window at Cristobal High School is a coral reef which fairly teems with living coral, sponges, Coelenterates, Echinoderms, small octopi, and numerous molluscs, arthropods, eels, rays, sharks, barracudas, etc. A few years ago a full grown whale washed upon the reef. Pearls have been fished commercially in the Pearl Islands which lie in the Gulf of Panama a few hours by boat from Balboa. Undisturbed jungle may be found a few miles from either of the high schools or at Barro Colorado Biological Station. Biological problems beset Canal Zone homes. Termites, ants, sand flies and cockroaches are always problems. If our closets are not made dry by electrical heaters molds, mildews, and other fungi grow rampant and destroy our clothing, films, books, leather goods and the like. Unique special adaptations exist abundantly. A mangrove swamp presents an impenetrable thicket of stilted roots upon which live molluscs in great numbers, thus giving some measure of credence to the statement that "in the tropics oysters grow on trees!" Nothing seems quite so blue as the Morpho or royal blue butterfly. "Thorn bugs" resemble real thorns so closely they are difficult to differentiate. Lives here a large frog which eats snakes, bats, lizards, mice and the like. A specimen which lived in the general science laboratory at Cristobal High School for over seven years ate a snake some fifty-four inches long. It took him forty hours to do the job, but the achievement was sufficient to make him immortal in the pages of the *National Geographic Magazine* in an article written by Kenneth W. Vinton in the May, 1938 issue of that publication. The strangler fig begins life as a simple and harmless little vine which grows to such gigantic proportions that it "strangles" the life out of its host tree. Bullhorn acacias live symbiotically with belligerent ants. The tree furnishes food and shelter while the ants protect against aggressors with their painful "stings." Iguanas break off their tails to escape would-be captors only to grow back a new tail—or sometimes two—at their leisure. This list could be extended indefinitely.

Primitive San Blas and Darien Indians live within 75 miles of the Canal Zone and are accessible for study. The former live on the numerous coral islands in the Gulf of San Blas, an arm of the Caribbean. Here cocoanuts, which abound, are used for money, and the race, which is remarkably pure, is formed into

a matriarchal society. Long-continued inbreeding has resulted in the appearance of numerous albinoes or "white Indians" or "moon children." All women and girls wear gold nose rings and ear ornaments and elaborate, showy costumes. Men dress very prosaically while boys go completely naked until the age of puberty. All San Blas Indians are excellent boatmen.

Scarcely 50 miles to the south of the San Blas Indians, but separated from them by a mountain barrier, the Darien Indians live along the rivers which drain into the Pacific. These two groups of Indians are widely different physically, ethnologically and culturally. The Darien people are among the most primitive Indians yet in existence in the Western Hemisphere. The men wear only the most meagre of loin clothes while the women wear only short skirts wrapped about the hips, leaving the breasts uncovered. Both sexes paint their bodies gaudily at all times. Culturally, they are far inferior to the San Blas people. It is not often that high school pupils have an opportunity to study such primitive people at such close range.

The problems of healthful living in the tropics are considerably different from those in the United States. White man has not fared too well in these climes. Fungus infections prevail. About 50% of the students in the Canal Zone high schools have skin fungus infections. Although yellow fever has been so completely wiped out that there has not been a local case in over 35 years, malaria is still with us. Much work, involving many thousands of dollars annually, goes into mosquito control. Typhoid and dysentery must be guarded against at all times. Palo Seco Leper Colony is maintained for some 125 sufferers of this dreaded disease and is located only a few miles from Balboa. Health is so important here as to have international significance. For many years Canal Zone doctors by treaty have had the final say over health conditions in both the Canal Zone and the adjoining Panamanian cities. Quarantine doctors inspect all incoming ships. Children must have diphtheria inoculations while all persons of all ages must take typhoid and smallpox vaccinations at regular intervals. A few years ago Dr. C. A. Mills of the University of Cincinnati discovered that native Isthmian diets are grossly deficient in vitamin B_1. An increasing number of Canal Zone dwellers are now augmenting their diets with B_1 and other vitamin concentrates. Health problems are considered sufficiently important that all Panama Canal and Panama Rail-

road employees and their families are provided with free medical care.

The importance of sanitation at this "Crossroads of the World" can scarcely be overemphasized. Perhaps no place in the world better shows the values of sanitation than does the Canal Zone. History shows this to have been one of the world's worst pest holes, but now, with carefully controlled sanitation, our death rate is lower than that of most large American cities. However, it is only fair to point out that these statistics may not mean all they would indicate. All employees stand a relatively thorough health examination before appointment, and upon retirement employees must leave the Canal Zone since only active employees are permitted to occupy quarters. The fact remains that life insurance companies continue to rate up the premiums on policies of Canal Zone citizens. Nevertheless, health conditions here are very good, and much of the credit goes to the sanitation workers. Extreme sanitation has made houseflies so scarce as to be uncommon. One can go for days or weeks at a time without seeing one. Mosquitoes, while not exterminated are fairly well under control. The splendid water supply has already been mentioned. All local meats and many other foods are carefully inspected by the Health Department before distribution and consumption. While at present our supply of fresh milk is inadequate, that which we do have is produced from high grade, healthy animals under the most sanitary conditions. Only by such vigilance in sanitary matters is the Canal Zone able to maintain its excellent health record.

We have discussed here certain ways in which we feel general science must be modified in order to meet the needs and interests of Canal Zone pupils. These examples are intended to be suggestive rather than exhaustive. In addition, of course, we give the fundamental principles of science in the various fields considered above and include the usual general science instruction in heat, air, water, mechanics, light, chemistry and the like.

Because of the modifications suggested above it follows that our laboratory work is modified accordingly. It involves the consideration of the various materials mentioned above, individual experimentation, classroom demonstrations and numerous field excursions.

As suggested previously, no single textbook is adequate for our needs. Instead we use several textbooks and have in the

classrooms numerous reference books and magazines which pertain to this region, particularly those which give a scientific slant on this environment. Certain selected examples of the more dependable reference materials are listed at the end of this article.

Standardized tests in general science are likewise not satisfactory for use here since they are made to apply particularly to States' materials. We administer them, and our pupils make good showings. Frankly, however, we doubt their value as an accurate measure of our pupils' knowledge of general science inasmuch as the content of our course is greatly modified from that ordinarily given in the United States. There is need here for local tests which are more or less standardized for our own situation.

In this discussion we have tried to point out, first, that the Canal Zone is a most fascinating place in which to study high school general science and, second, that the content of any worthwhile general science course must be modified to make use of the local environment. We have suggested some of the ways in which we have adapted our course to the local situation. It is hoped that other teachers in other communities may be stimulated to make similar adaptations in the use of materials close at hand. Only by such local adaptation can the general science course attain its full value and afford its full measure of interest and meaning in the lives of high school students.

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INADEQUATE SALARIES

Except in a comparatively small number of cities, the teachers of every state were underpaid before the war. Since the beginning of the war teachers' salaries have not been adjusted sufficiently to meet increasing costs of living. The cost-of-living has increased over 20 per cent while teachers' salaries have increased less than 7 per cent. Unless a way is soon found to relieve the financial difficulties of hundreds of thousands of teachers, our schools will suffer irreparable injury and millions of our children will be handicapped throughout their lives.

GOOD TEACHERS LEAVE THE PROFESSION TO LIVE

Over one hundred thousand trained and qualified teachers have left our schools since the war began. The supply of competent, well-trained beginning teachers has been inadequate to fill their places. As a result many persons not adequately prepared have been employed as teachers. Important subjects of instruction have been dropped. Classes have been overcrowded. An alarming reduction in the quality of the education of America's children is being threatened. Unless a remedy is found conditions in our nation's schools will become rapidly and alarmingly worse.

WAR WORK AND TEACHER'S SALARIES

No group in America has worked more conscientiously or energetncally to promote the war effort than teachers. Meanwhile, however, their salaries have risen only slightly while the cost of living has risen rapidly. Since teachers were already greatly underpaid when the war started, it is not surprising that scores of thousands of them have been drawn out of the profession by the higher salaries paid in both industry and government.

WILLARD E. GIVENS

SOME TECHNIQUES IN THE TEACHING OF CONSERVATION*

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As part of a three-year Co-operative Science Study in Secondary Schools under the direction of Dr. S. R. Powers, Teachers College, Columbia University, a series of three pamphlets were prepared during 1941–1942 by the author of this paper. The first of these, entitled *Plant and Animal Communities*, discussed the development of plant and animal communities, the interdependence of plants and animals within these communities, and the relation of the human community to the plant and animal community, or in few words, an ecological approach to the study of conservation. Summaries and suggested projects accompanied each chapter. A list of books closely related to the material of the pamphlet was given at the end. Maps and tables were used throughout. Report blanks accompanied the pamphlet to secure student reactions to pamphlet material, and student estimates of pamphlet concepts as applied to their own communities.

Fifteen classes in eight high schools and one eighth grade class used *Plant and Animal Communities* during the second semester of 1941–1942. Six of the eight high schools are participants in the science study mentioned above.

Motivating devices and useful techniques employed in teaching the pamphlet are worthy of mention. An outline and brief discussion will present the procedures in various schools.

Pre- and post-tests on

1. Information of the pamphlet.
2. Skills in interpreting maps, tables, and graphs; in analyzing visual materials; and in using keys to identify trees.
3. Attitudes about conservation of soil, water, animals, and forests; attitudes about planning for future use of natural resources in city, state, and nation; and attitudes about community problems of pollution, smoke and erosion.
4. Outdoor interests.
5. Vocational interests.

These tests proved useful as instruments for testing the kind and amount of information, skills, attitudes and interests possessed by young people, as well as changes which might occur in

* Presented at the Annual Meeting of the Central Association of Science and Mathematics Teachers, Nov. 28, 1942.

these areas as the result of studying and discussing the pamphlet.

Projects

I. Laboratory projects, such as
- Scrapbooks on sand dunes, bogs, swamps, and rock bluffs
- Charts on succession in sand, water and rock
- Maps
  - climax communities
  - school nature preserve
  - rainfall and vegetation
  - soil regions and agriculture
  - planning regions
- Constructing a model community
- Exhibits of plants and animals to show relationships
- Study of seed dispersal and animal migration
- Making an indoor garden (cacti; aquaria; terraria)
- Growing tree seeds
- Making a calendar to show dates of appearance of spring and summer birds
- Making tables or diagrams on wild flowers to show time of appearance, color, fragrance, pollinating agents, and so forth
- Making and studying kodachrome slides
- Microscopic studies of roots, stems, and leaves of water, land, and desert plants; algae, fungi, mosses, and ferns
- Study of parasitic plants and animals
- Study of different species of woods and their uses

II. Field work, such as
- Succession studies in sand dunes
- Succession studies in lake, bog and on rock
- Study of climax communities
- Habitat studies
- Trip to study demonstration of succession in a school showcase
- Erosion problem on school terrace studied and plans made to control this erosion
- Identification of trees
- Trip to State Forest Preserve
- Study of seed dispersal in field
- Studies of soil and air moisture, soil and air temperatures, soil acidity, wind velocity, and effects of sun and shade in School Nature Preserve
- Study of a vacant lot to determine abundant and controlling species of plants and animals
- Quadrat study in a woods
- Collecting galls, parasitic plants, water plants, insects, and tree fruits
- Taking photographs of successional stages, plant and animal communities, man's interference with plant and animal communities

III. Community studies, such as
- Study of resources and problems in the county
- Reports and essays on conservation in the county
- Visit to city forests
- Study of pamphlets and maps from Area Conservation Office and State Experiment Station
- Study of pamphlets and maps from State Conservation Department
- Visit to city parks and wildlife preserves

Study of stream and air pollution
Erosion problem in state and community
Study of forest resources in state, flow of lumber into city or state, and uses made of it
Study of ways in which wood is substituting for metals in community
Study of insect pests and damage
Visit to regional or state planning office to secure information on problems of the area and better use of natural resources

Hobby-development from project activities, such as
Reading science and conservation books
Studying for Boy Scout conservation merit badge
Becoming a member of community conservation club
More outdoor activity—hiking, bicycling, camping and outdoor sports
Making collections—insect pests, snakes, galls, tree fruits and tree wood specimens
Photographs in the out-of-doors
Gardening
Landscaping the home grounds
Identifying plants by use of keys
Bird-banding

Student discussions outside of class, as indicated on report blanks, on
Erosion
Balanced communities
Interdependence of plants and animals
Succession of plants and animals
Conservation
Tennessee Valley Authority
Forest fires
Protecting wildlife
Planning by states and nation
with
Parents
Brothers
Sisters
Uncles
Schoolmates
Other friends

These discussions outside of class were no doubt stimulated by class activities and class discussions. The significance of such discussions lies in the fact that students actually carried conversation on the topics studied outside of class and even into their homes.

Student reports and essays (oral and written)
Keeping my favorite woods a balanced community
Man-made communities of plants and animals
Preventing fire in our forests
How can America prevent deforestation?
How a knowledge of succession will help the farmer (or forester, ranger, planning board)
Why forests are called a "renewable resource"
How to prevent erosion
Succession in my countryside

Why I should like to study forestry
Book reports, such as
Forest of Adventure by R. L. Ditmars
America Begins Again by K. Glover
Over African Jungles by M. Johnson
Audubon's America by D. C. Peattie
Deserts by Gayle Pickwell
Bambi by F. Salten
Animal Treasure by I. T. Sanderson
From Forest to Furniture by M. H. Sherwood
Boys' Book of Insects by E. W. Teale
Anecdotal records of class proceedings by teacher or appointed students.
Student diaries of daily happenings in class and outside of class while studying *Plant and Animal Communities.*
Student-teacher conferences on,
Pamphlet subject-matter
Attitudes and opinions on succession, balanced communities, human versus plant and animal community, and planning for future resources
Avocational interests
Vocational interests
Individual acts of conservation
Co-operation with community agencies of conservation
Report blanks to secure student estimates of pamphlet ideas and concepts as applied to their own communities.

Direct quotations are better in this portrayal of student reactions than mere interpretation on the author's part. Students state that the ideas and concepts were important because:

"They show how our community and others got started."

"There is much erosion in our state and many farmers."

"Problems of our region are pollution of the Hudson River, water shortage, insect pests, wasteful lumbering, erosion and wildlife shortage."

"We should know the problems of our community; we should know our resources and how to use them; some of us will be farmers; we should know more about the governmental agencies and their work in our community."

"As future citizens we must improve our communities and this information will help us; there are many farms near by; the problems presented are those any community should know and be concerned about."

"We are a farming community; this is an agricultural state; there is definite need for conservation in our community; our public should be educated in these ideas and concepts; our town is small and we seem in closer contact with nature."

"A great deal of the information is taken from our region; natural succession has been destroyed in our community, it is

well to know what to do about it; our problems are also the problems of other communities; the community is a starting place; often well-to-do people neglect our resources, particularly the limited resources; all communities, no matter how small must co-operate."

The varied techniques thus presented are indicative of the approaches and devices which teachers are using to develop the dynamic concept of conservation. Embodied in this dynamic concept is the conversion of latent resources into active usable human resources, the flow of products from industries, farms and laboratories to the battle-front and home-front, the practice of economy in use, finding of substitutes which will work just as well if certain resources are limited or show indication of becoming short through war use or war barriers, and planning for the future of city, state and nation. The youth in our schools today will be the farmers, foresters and city planners of tomorrow.

HIGH-SPEED METHOD OF SAWING HARD AIRCRAFT

Aircraft metals are being sawed at extremely high speeds by a new method, Arthur A. Schwartz of the Bell Aircraft Corporation, announced at the meeting of the American Society of Tool Engineers today.

Engineers started with a wood saw on which the blade travels 12,000 feet per minute. After making some carbon steel blades, they experimented with such factors as temper and set of the teeth. Results were surprising.

"We cut non-ferrous materials and ferrous materials," Mr. Schwartz declared, "soft steels and very hard steels, in fact, the harder the steel, the easier it cuts."

Two half-inch pieces of armor plate are sawed by the new device at one time. Heat generated by friction of the saw teeth is so intense that the metal is melted and most of it turns into gas.

Eighteen such saws are now in use at Bell Aircraft for such operations as trimming of aircraft metals, and making boiler plate dies.

Cutters, used to mill aircraft metals, can be made faster, cheaper and better, Mr. Schwartz also suggested to the engineers. Remove six out of seven teeth on the large multi-bladed milling cutter commonly in use, he urged. Only four teeth are needed. With each taking a healthy bite, faster production and smoother finish results. This simplified machine also removes the old problem of not having enough power.

Pounds of critical high-speed steel are saved; cost and time are saved; and the cutter lasts longer at faster speeds.

To further conserve high-speed steels and carbides and speed production, Mr. Schwartz recommended that engineers use a wider selection of cutting materials for metal working.

Cast alloys have not been used as much as they should, he asserted. Tantung, one of the alloys, is now giving better results in certain phases of aircraft production than the usual highspeed steel or carbide.

PHOTOGRAPHIC AIDS TO TEACHING

III. AN APPARATUS FOR MAKING FILM STRIPS AND 2×2 SLIDES

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A most potent new tool for the teacher of science is the 2×2 projector, which combines economy with easy portability and remarkable efficiency. Many schools now equipped with this apparatus will find that its usefulness is severely limited by the lack of suitable slides and film strips (except in the fields of aeronautics and mechanics). We have been able to build up a large file of excellent slides with the aid of a simple contrivance to be used with a 35 millimeter miniature camera. The apparatus described was made for the Perfex Camera but can be adapted to any camera with a removable lens. It enables the operator to focus and compose the image on a ground glass screen before taking the picture. Commercial attachments have been manufactured for this purpose but are now very difficult to obtain and often cost more than the camera itself. The apparatus described in this article can be made from scrap metal by anyone who can manipulate a lathe.

The parts of the apparatus, as shown in Figure 1, are a base plate for the camera lens, a sliding plate which accommodates the camera and the focusing hood, a lock ring for the camera, and two set screws. The base plate is made of steel at least $\frac{3}{8}$ inch thick, 2 inches wide, and about 6 inches long. The width of this plate will vary with the diameter of the camera lens. In the center of the base plate we drill a hole and thread it to hold the camera lens. This may be done on a lathe.

The sliding plate must be the same width as the base plate but may be much thinner—$\frac{1}{8}$ inch will suffice. Its length will depend upon the size of the camera—for the Perfex a length of 11 inches is satisfactory. We drill and thread two holes in the sliding plate, each of the same diameter and thread gauge as the opening in the base plate. The position of these holes should be carefully planned in accordance with the proposed location of the camera and focusing hood on the sliding plate.

The locking ring is designed to hold the camera to the sliding plate and to form a light-tight joint. It is simply a short length of brass pipe turned and threaded on the lathe to pass through the hole on the sliding plate into the lens bed of the camera.

The focusing hood is a small box made of sheet metal soldered together. This box may be $2\frac{1}{2}$ inches long, 2 inches wide, and 2 inches deep. It is soldered to a short length of brass pipe and turned and threaded to fit into the second hole on the sliding plate. An L-shaped piece of metal inserted into the box carries a piece of ground glass for focusing. The height of the glass can be adjusted by wing nuts.

Two L-shaped pieces of metal are screwed into the sides of the base plate in such a manner that the sliding plate can be

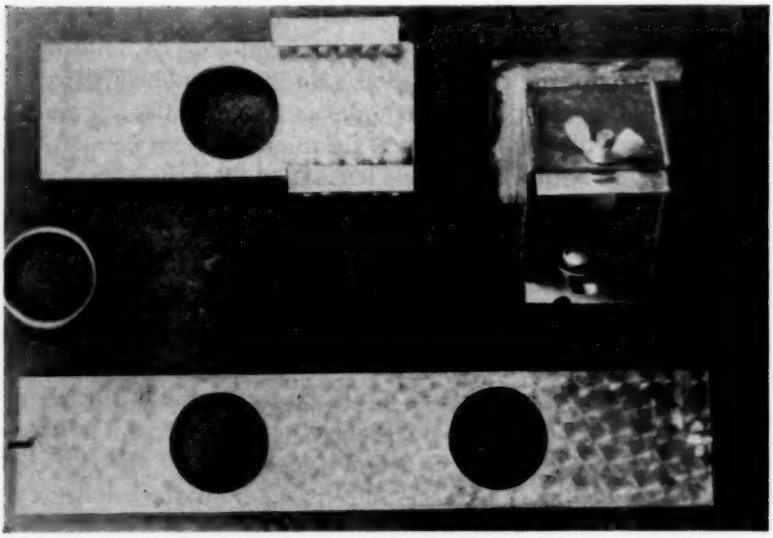

FIG. 1. A.—Base plate, with hole threaded to receive camera lens and metal brackets forming groove for sliding plate.
B.—Locking ring for camera.
C.—Focusing hood with ground glass in position.
D.—Sliding plate, showing threaded holes for camera lock ring and focusing hood. Set screws are in position at both ends.

passed under them and slide easily over the base plate. After this has been done, and one can drill two holes through the pieces into one side of the base plate. The holes are tapped to hold the tripod screw or copying stand screws. Set screws should be inserted into the ends of the sliding plate so that the hole in the base plate will exactly line up with the two holes in the sliding plate.

The entire apparatus is assembled as illustrated in Figure 2. The lens of the camera is removed and screwed into the base

plate. The camera itself is fastened to the sliding plate with the aid of the locking ring. The apparatus may be used with a tripod, but a convenient copying stand, such as the one shown in the photograph, can easily be made from discarded pipe lengths and a base board. The apparatus is standardized by removing the back of the camera and placing a piece of ground glass over the film track. After the lens has been focused on some test object, the sliding plate is slid over and the focusing hood brought into position over the lens. The ground glass in the hood is then ad-

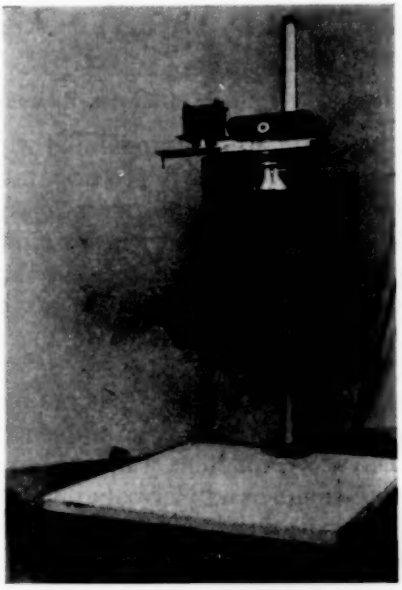

FIG. 2. Copying attachment mounted on copying stand. The camera lens is screwed into the base plate and the sliding plate is in the taking position, with the camera above the lens. Focusing is accomplished by moving the sliding plate so as to bring the focusing hood into position above the lens.

justed and permanently locked in focusing position. The area covered should be marked off on the focusing glass for future use. Once these adjustments have been made it is unnecessary to change them unless a different camera is used.

When taking pictures with the apparatus, the focusing hood is slid into place and the lens is screwed in or out of the base plate until the image appears in sharp focus. The camera is then slid into position, as shown in Figure 2, and the exposure is made.

One can easily make 36 exposures within a half hour. Pictures from textbooks or magazines are copied with speed and facility. The film thus prepared can be used directly as a strip film or cut up and mounted as 2×2 slides. The best film to use for this purpose is 35 mm. Positive film, which can be bought in 50 foot rolls at about one dollar per roll. Almost 300 pictures can be made on one roll. Pictures of line drawings or textual material should be projected directly as negatives. Reproductions of half tones can be printed on Positive film or processed by reversal.

AN IMPROVED ELECTROLYSIS APPARATUS

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Teachers of science are often disappointed with the performance of the common types of electrolysis apparatus. Some are so fragile that they do not stand the rigors of secondary usage, others are sturdy enough but do not permit much gas to be collected. The apparatus described in this article does not have these disadvantages and does have some marked advantages over most of the equipment available to the high school instructor.

The device is constructed of parts that are found in any secondary laboratory. It is simple enough to be assigned as a construction project to any competent student. Two pieces of platinum from a broken commercial piece of apparatus supplied the electrodes. These were carefully soldered each to a piece of #16 copper wire about 3 inches long. To these connectors there were soldered long pieces of #30 enamelled copper wire. A 400 ml. beaker, a large cork to fit it some rubber tubing, and two thistle tubes were all that was required to complete the apparatus. Since the copper wires leading to the electrodes come in contact with the electrolytes that are to be used, it was necessary to protect them from corrosion. The soldered joints as well as the wires were first coated with rubber cement and then heavily waxed. This treatment will not protect the wires against prolonged immersion but is satisfactory for short periods of use.

The thistle tubes were mounted in the cork as shown in the illustration, the wires from the electrodes leading up through the stems and then being folded back down the outside of each stem so that the gas outlet tubes could be forced down over them. Unless the rubber tubes form a very snug fitting connection, the gas that is generated will leak out along the wire and

cannot be collected. To prevent this leak it may be necessary to twist a piece of #16 wire tourniquet fashion around the rubber tubing and tighten with a pair of pliers. The rubber tubing should be long enough to carry the products formed during the electrolysis to a gas collection trough as shown in the upper right of the illustration. The thistle tubes should be close together to secure the minimum resistance and maximum current.

To set up the apparatus it is only necessary to place three inches of solution in the beaker, lower the electrodes into the solution, and connect a low voltage source of direct current to

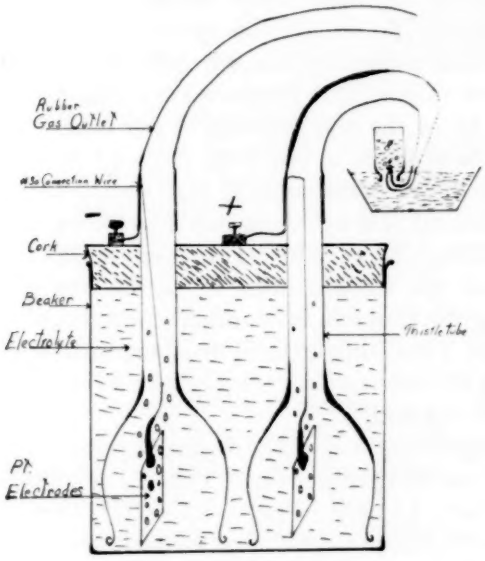

FIG. 1

the connections shown in the illustration. When the apparatus is first connected it is necessary to allow it to run for several minutes in order to expel the air that originally filled the tubes. Using a voltage of 6–8 volts it is possible to fill a small test tube with hydrogen or chlorine in three minutes.

By placing pinch clamps on the outlet tubes and closing them it is possible to force the liquid out of the thistletubes and stop the action. If the evolved gases are collected in graduated cylinders or graduates the quantitative relationships of the volumes may be seen. If the average amperage and the exact time of current flow is noted a reasonable approximation of the electrochemical equivalent of gases may be obtained.

PER CENT WITHOUT THREE CASES

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The old fashioned method of teaching per cent includes the so-called three cases. These cases are: finding what per cent one number is of another, finding a certain per cent of a given number, and finding a number when a certain per cent of that number is given. More briefly, the three cases of per cent are all represented by the equation—A per cent of C equals B, where A, B, or C is the unknown value depending upon which is the case in question. The use of these three cases of per cent means that the student must memorize three different methods of solving a problem in per cent. It also means that the student does not need to know the real meaning of per cent.

The algebra student in studying per cent can reduce everything to the simple statement: A per cent of B is C, which in turn is written $.01\,AB=C$. As mentioned above, any one of the three letters may be variable. This method has the objection, however, that the student must know the methods which are applicable to the problem in working it out in the normal algebraic fashion. Thus, this method does not fit in with the standard training of business students, or of any who have not had some work in algebra.

Before considering a new short-cut, suppose we examine the value of the teaching of per cent. That is, what should the student learn from a study of per cent? Also, when we have settled the aim of the course, we must answer this further question: does this short-cut conflict with that goal? The simple numerical problem in per cent gives the student considerable practice in the fundamental operations of addition, subtraction, multiplication, and division. The more important word problem involves the actual translation of that word problem into mathematics, the solution of the mathematical problem and the retranslation into the terminology of the original problem. Our aim is to make this entire process easy for the student.

The translation of the original problem into mathematical symbols and the translation back into the original terms demands a fair understanding of the meaning of the entire process. The mathematical manipulation then can be simplified without destroying any of the value which the student may get from solving the problem. Hence, in practical applied mathematics,

our aim is to make the actual mathematical manipulation as simple as possible.

One short-cut which may be used to solve all three cases of per cent works as follows: any per cent problem may be reduced to the form: *A* per cent of *B* is *C*, where two of the letters are actual numbers and the third is the quantity to be found. If the student draws a box around the per cent, the "of" and the number following the "of," he will find that either two numbers are in this box, or that a number and the unknown are in the box. If the box contains two numbers, these two when multiplied will give the answer to the problem. If the box contains one number, then the answer to the problem is found by dividing by the number inside the box. In any case, of course, the per cent is changed to either a decimal or a fraction before the multiplication or division is performed.

In case the student does not wish to reduce the problem to the form, *A* per cent of *B* is *C*, he may think of the unknown as a blank or as the word "what." He may write: ____ per cent of a number is another number, or a given per cent of ____ is a number, or a given per cent of a number is ____. Using the "what" these may be written: what per cent of a certain number is another number, or a certain per cent of what is a given number, or a given per cent of a certain number is what. Every-one of these is just another way of writing: *A* per cent of *B* is *C*, where a ____ or a "what" is used for the unknown letter. As another approach, the problem may be stated: *C* is *A* per cent of *B*; the entire above discussion applies.

Suppose we consider three examples in order to see the actual operation of the short-cut.

1. What is 5% of 200?

The student writes the problem down as above or, of course, he may use a letter, a question mark, or a long dash in place of the "what." Then he places the box around the per cent, the "of" and the number following the "of."

What is $\boxed{5\% \text{ of } 200?}$

Then he notes that two numbers are in the box; hence he multiplies .05 by 200 and finds the answer to be 10.

2. 38 is 20% of what number?

Again, this is written down by the student and the box is drawn as below.

38 is $\boxed{20\% \text{ of what?}}$

Here, there is but one number in the box, so the student divides by that number: 20% which is .20. The answer is found to be 190.

3. Among the 88 candidates for a particular job, 22 were found with defective eyesight. What per cent of the group had defective eyesight?

In order to set this problem down in the standard form, the student must have sufficient understanding of per cent to translate the last sentence of the problem into the standard form by noting the following:

88 is the same as the group

22 had defective eyesight

Therefore the problem becomes:

What per cent of 88 is 22?

Then the student draws the box around the per cent, the "of" and the number following, as follows:

| What per cent of 88 | is 22?

Again there is one number in the box, so that the student must divide by that number: 88. The answer is found to be $\frac{1}{4}$ or .25 either of which is then changed to 25% because the problem asks for a per cent.

It must be remembered that this is a purely mechanical short-cut and it does not instruct the student in any way, in the actual meaning of per cent. This method merely takes advantage of the per cent sign and the word "of" and uses their positions in the problem as a clue to the solution. The aim of this short-cut is to make the actual mathematical operations as easy as possible. This short-cut should be used in conjunction with a thorough treatment of the meaning of per cent, that is a treatment such that the student develops the ability to translate the per cent problem into the mathematical form. Then the student understands what he is doing and the short-cut saves a little time and worry in the mathematical manipulation. If the student uses the algebraic method of solving the problem, this short-cut might be of value as a simple check.

I have not the slightest doubt that the study of the liberal arts will not only survive this war but prosper in the days of peace.—*James Bryant Conant, President, Harvard University.*

THE CONTRIBUTION OF SCIENCE IN THE DEVELOPMENT OF ART

PART I

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Editor's Note. This is Part I of the second of a series of two articles concerning the contribution of mathematics and science in the development of art. The first article discussed the place of mathematics in art and appeared in the December, 1942, issue of School Science and Mathematics. Part II of this article will appear in a later issue.

Artists and laymen alike have always taken for granted the contributions of science to art productions. A great painting or beautifully designed building seldom impresses the observer with the tremendous amount of scientific research which was carried on both in the artist's studio and science laboratory in order to produce the work. It is the purpose of this article to point out those phases of painting which are influenced by and indebted to the sciences.

The simplest way of showing the need for science in art is to present violations of scientific principles that are evident in paintings on exhibit. Critical analyses of many creations show the scientific ignorance of artists by their drawings of airplanes that could not fly and of ships that could not sail. While Michelangelo painted gigantic human figures which were deliberately distorted in size and proportion to overpower the mind with a feeling of insignificance before the Almighty Spirit, this "artistic license" had to be justified. However, the blind violation of science is now unacceptable and artists are finding that the contemporary public is demanding a more rigorous conformance to the principles of science. The modern painter is meeting this demand by training himself thoroughly in all those areas of science which have significance to art. This discussion is concerned with science as it affects the media with which the artist works, the subject matter that science offers and the untapped sources of artistic inspiration yet available in the sciences.

I. Science Involved in Artistic Media

Science as related to painting media may be thought of in

terms of the painting ground, the pigments and the preservation and restoration of pictures.

The ground on which the picture is painted has received voluminous treatment because the artist has always been concerned about painting on the most permanent surface possible. He anticipates the damage which may come to his work from chemical reactions, humidity, light, temperature, insects, dust, and other environmental circumstances. For example, Michelangelo, while preparing to paint his frescoes in the Sistine Chapel of the Vatican, ordered a new end wall constructed in front of the old. This new wall leaned out slightly at the top so that the dust would not settle on the painting and so the painting might better be observed. This double wall provided a ground that had the necessary ventilation for the protection of the frescoes from outside dampness and temperature changes. He used carefully selected bricks and mortar in order to exclude the dangers that might come to the frescoes from calcium sulphate, sodium sulphate and magnesium sulphate.

In a general study of grounds, any surface that will receive and hold pigments may be utilized. Many egg-tempera paintings have been applied to such surfaces as zinc, porcelain, copper, steel, mahogany and other woods. Most of these surfaces, however, must receive a special preparation of gesso which is a combination of glue-size and whiting. Canvas grounds may be made from a great number of materials such as flax, hemp, linen, cotton, creton, shirting, jute, muslin, sailcloth, sackcloth, ticking, twill and cambric. Each of these surfaces has its special advantages and disadvantages. In preparing the canvas to receive and hold the pigments, priming coats of glue, sizing, varnishes, gelatins, chalk, clay, marble-meal, zinc-white and titanium may be employed. Modern concerns that supply art materials have found it necessary to employ large staffs of research technicians for the purpose of solving the chemical problems involved in ground production. The artist is grateful to be relieved of the responsibility of experimenting with grounds and jeopardizing his works. He can now give his time to artistic production while the scientist solves the technical problems according to the requirements of the artist.

In the field of the graphic arts, the various techniques of etching are dependent upon a knowledge of chemistry. The artist must become familiar with the acids used in the biting baths, with the chemical composition of various plates, and with the

acid resisting materials employed directly on the plate. He is also concerned with the character and depth of the bites which these acids make both in etchings and in photo-engraving reproductions.

Pigments and other media used in painting offer the most complex scientific problems that the painter faces. The selection of a palette of permanent pigments from among the tremendous variety of colors now available is made difficult by such factors as the effects of sunlight and atmospheric conditions on paints. Some colors completely disintegrate even under favorable circumstances and it is true that both preservatives and binding media influence colors. By exhaustive studies, chemists have solved many of these problems and have produced several series of enduring pigments.

Permanent colors come from inorganic and organic sources. Natural organic sources include the earth colors such as limonite (yellow ochre) and hematite (red ochre). These are found in almost pure form in clay deposits existing in all parts of the world. Other inorganic colors are composed of chemical elements and compounds that have proven to be extremely valuate in the artist's palette; these are zinc white, the cadmiums and the cobalts. Synthetic colors now popular with artists are the aniline dyes made from coal tar. They are strong colors but have a tendency to overpower other colors and are apt to break down under light.

The inorganic colors include the unstable vegetable hues such as lakes and madders derived from yellow berries, red berries and oak bark (quercitron). For example, indigo is a natural plant pigment and dye obtained from the decomposition of indican which is found in the sap of various herbaceous shrubs. Although a great variety of pleasing colors are derivable from organic substances and synthetic processes, the artist prefers the more stable, though sometimes less colorful, minerals. No painter is lacking in this knowledge of pigments; nor is he deficient in appreciation to the chemist for assuming the burden of tedious research in the science of color.

II. Science As Subject Matter for Art

In the development of art, it is generally recognized that the social sciences have made the greatest contributions, but the usual analysis of subject matter in art has overlooked the influence of natural science and life science. For example, Eugen

Neuhaus in his *The Appreciation of Art* classifies subject matter in a manner which leaves scientific contributions almost completely out of the picture. The following categories with illustrations are our own interpretations of the ranked classifications of Neuhaus.

1. *Religious symbols.* Madonnas, crucifixions, last suppers, adorations and Biblical stories.
2. *Aristocratic ideas.* Portraits and pictures including representatives of the people such as czars, emperors, caesars, dictators, nobles of the court and officials of the government. These works were usually done by court painters.
3. *Social ideas.* Pictures of common people and their daily activities at home and in the community.
4. *Political ideas.* Pictures that bring messages of social reform or would influence political situations. Paintings of riots, bread lines and over-worked drudges; of crafty lawyers and judges; of money lenders, bankers and medical quacks; of self-seeking politicians, and demogogic labor leaders.
5. *Emotional ideas.* Art that aims to portray beauty in man and nature; that idealizes landscapes and people; that attempts to perfect nature's productions to approximate man's aesthetic concepts.
6. *Economic ideas.* Art designed to glorify the wealth and position of the purchaser.

It is our intention to discuss the influences that the sciences have made in the progress of art and we shall give brief treatment to each of the scientific fields included in the following classification.

A. Life Sciences
   1. Anatomy and Physiology
   2. Zoology
   3. Botany
   4. Agronomy

B. Non-Life Sciences
   5. Chemistry
   6. Geology
   7. Geography
   8. Physics and Mechanics
   9. Astronomy

A. Life Sciences

1. Anatomy and physiology. The Italian Renaissance brought a reinvigorated appreciation of anatomy and physiology in relation to painting and numerous artists of great talent devoted much of their energy to the study of the body. In the 15th century, the German artist Albrecht Dürer was forced, through

lack of access to previous scientific research in anatomy, to spend many hours in original study of structural problems before he felt ready to use the human figure as subject matter for art. His anatomical diagrams are as inspiring to the contemporary artist as those of the great Leonardo da Vinci. Their enthusiasm was echoed by Rembrandt and Keyser in their pictures entitled "Anatomy Lesson." American artists have shared this interest and have produced such pictures as the "Agnew Clinic" and "Gross Clinic" by Thomas Eakins and "Controlled Medicine" by William C. Palmer.

At the present time the science of anatomy offers the artist comprehensive information on the construction of the body and the origin, insertion and action of all muscles. Every properly trained artist is fortified with intensive studies in the classrooms and laboratories of the anatomist and physiologist so that his artistic creations emanate from a scientific and an aesthetic appreciation of structure and function of the body.

2. Zoology. Zoology has made a great contribution to the artist through its analysis and classification of animal life, insects, marine life and birds. Since laymen and consumers of art are becoming more rigid in their standards of scientific accuracy in paintings, zoology has become an essential area of study for many artists.

Among the many painters who have become famous for their work in the zoological field, the most outstanding American is John J. Audubon, 1785–1851. He was a fanciful painter who roamed the forests and swamps from Ohio to the Carolinas seeking beauty in nature and accurate information of wild life. His books and drawings of animals and birds have set an unexcelled standard for fidelity and coloration.

The Dutch still-life painters of the 16th and 17th centuries gained renown for painstakingly detailed studies of fish, rabbits, pheasants, quail, ducks, peacocks, lobsters, octopi, and all forms of wild game and domesticated animal life. The Americans, William Merritt Chase, 1849–1916, and Charles W. Hawthorne, 1872–1913, followed the patterns set by the Dutch masters. Oriental artists, working independently, have developed the art of linear design to a high degree and have applied their skill with outstanding success to marine life and to fowls.

An example of zoology applied to painting is Charles W. Peale's work, "Portrait of the Artist in His Museum." Here he reveals himself as a founder of zoological museums in this coun-

try and pictures an exhibit of stuffed birds, mastodon bones and animal exhibits.

3. Botany. Botany, as an organized science, has made a great contribution to the artist through the information assembled regarding plant structure, plant growth and favorable environmental conditions. The artist knows that he must be well equipped with botanical knowledge if he wishes to depict the aesthetic qualities of plant life. One of the first Americans to become interested in this subject was Thomas Cole, 1848–1901. Although uneducated and untrained in the technicalities of painting or of botany, Cole rose to leadership in the school of landscape painting. While growing up in the Catskill mountains he caught the poetic spirit of nature and was gifted in transferring his intimate interpretations of nature to canvas.

This science has accumulated innumerable specimens which the artist may use in his work. The contemporary artist Charles Demuth has used the calla lily for a painting which has gained national recognition through the Living American Art Series. Georgia O'Keefe has received world-wide acknowledgment for her studies of tropical plants.

A happy combination of zoology and botany is to be found in the scientific studies of Abbott H. Thayer, 1849–1921. He is considered the most important pioneer in the research of protective coloration in wild life and many of the principles which he discovered are now used in camouflage.

4. Agronomy. Man's dependence upon nature and his control of the soil are subjects that have been treated by many artists and may be classified as subject matter from agronomy. Millet's pictures, "Gleaners," "Sowers," "Reapers," and "Angelus" utilize the subject matter of agricultural activity. More recently produced, such pictures as the "Spring Turning" by Grant Wood shows the beauty of properly plowed fields; or "Fall Plowing" by Costigan and "Corn Husking at Nantucket" by Eastman Johnson are excellent uses of agronomy in painting. The work of state and county fairs, of 4-H clubs, of county agents and agricultural schools in stimulating interest in scientific farming have been used frequently as subject matter for art.

Muralists have been prolific in depicting every phase of scientific crop production and rural economy. Their paintings show the agronomist in his laboratory analyzing soils. They show the experimental farmer utilizing the most modern equipment in planting, plowing, cultivating and reaping. Painters interested

in the improvement of rural life have shown that newer methods in agriculture can elevate standards of living. They show how tenant farmers on wornout and eroded lands live in an impoverished condition and their pictures are eloquent propaganda for scientific farming.

With this discussion we conclude our treatment of the influence of the life sciences on the progress of art. In a later issue of SCHOOL SCIENCE AND MATHEMATICS will be published the second part of "The Contribution of Science in the Development of Art." In this article there will be a similar discussion of the influences of the non-life sciences in the progress of art.

NOTES ON VACUUM TUBE ELECTROSCOPE

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Further experimentation, and questions and comments in letters received, on the Vacuum Tube Electroscope (SCHOOL SCIENCE AND MATHEMATICS, 372, 46 (1943)), elicit the following:

The electroscope functions properly on alternating or direct current, of from 100 to 125 volts' line voltage.

The charge on a person, especially if he wears rubber-soled shoes, is often sufficient to produce curious and misleading effects unless he takes care to ground himself.

By *touching* the grid wire with a negatively charged rod, sufficient negative bias is put on the grid to completely extinguish the neon lamp; however, a strong positive charge brought near the grid wire, or touching the wire with one's finger, will re-establish the glow.

Shielding is exhibited by first showing a negative charge which extinguishes the glow when brought to within a yard or so, then holding in one hand a calorimeter can or wire gauze of the kind commonly used to show electrostatic shielding over—but not touching—the grid wire, and bringing up the charged rod with the other. The absence of effect is evident and striking.

Mr. H. D. Hatch, of Boston, makes the following correction in computation: Each electron on the grid controls the passage of 50 million electrons per second. (250 million electrons on the grid control a current of .002 ampere or 1.3×10^{16} electrons per second.)

IMPROVING PRIMARY GRADE SCIENCE BY PROBLEM TEACHING*

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Have young children any need for science? Should it be a part of the curriculum for the primary grades? If the scientific questions asked—and answered—by thirty first graders in the University Elementary School is a true indication of what we can expect of the wisdom and discernment of six-year-olds, we have long been neglecting many real learning situations in our schools. There certainly would never be the danger of a one-sided curriculum set up by adults whose interests have narrowed to one or two special subjects, for we, in the first grade, travel far during the year into the fields of physical, natural and biological science in our quest for satisfying answers to questions asked by this group.

Every child, without exception, is possessed of an inquiring mind. In fact we who work with small children often feel that they are over-endowed with this faculty! Children's questions begin long before language becomes a polished tool for probing and it requires strenuous and persistent effort on the part of parents and teachers to cope with the natural tendencies of children to ask questions.

At first children ask questions more to gain attention than to gain information. Three-year-olds frequently ask "What's that" and "Why" when they don't really want to know what it is and they rather definitely don't care why. They know that questions have the magic quality of bringing a definite response and they are quite pleased with the attention they gain from it.

Real questioning, of the "what, why, and how" type begins when children are about five and six years old. Then they begin to ask questions of definition, scientific questions, and questions to clarify concepts. Parents and teachers are likely to become so interested in this stage of questioning that in their eagerness to answer questions they unwittingly destroy the fun the child has in finding the answers to his own questions.

All too frequently we teachers give long-winded and uninteresting answers which are well beyond the child's understanding.

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* Read at the Elementary Science Section Meeting of the Central Association of Science and Mathematics Teachers, November 1942.

When we do this we are working toward the ultimate effective stifling of an inquiring mind just as surely as when we say "I don't know. Go away and don't bother me." The teacher's responsibility in answering children's questions is a subtle and shifting one. We must be tolerant of children's questions, we should encourage them to be curious, should let them know that they have a right to check things which they do not believe, and should let them search out truths for themselves.

In the first grade at the University Elementary School we plan our program in science with these aims in view. We try to capitalize on the curiosity of the children and we frequently plan periods when the class can ask questions. The stimulus for these questions may be caused by objects which the children bring into the room. Or it may be brought about through careful planning on the part of the teacher to stimulate interest in a particular problem to be studied. The greater portion of our question-raising periods are originated in this latter way.

Our science program is planned to develop certain broad generalizations within specific scientific areas. However, it is not so definitely planned and rigidly set up that we make no use of the leads initiated by children as they observe and bring in interesting specimens. To the contrary, we have found that the experiences of children which are only incidentally scientific may serve as powerful motives for learning new ideas and for providing opportunities for applications of learning gained during the regular science period. Unfortunately, however, the children's immediate interests in science are infrequent and sporadic, and a science curriculum based solely upon questions which arise incidentally in connection with other curricular activities is apt to result in a "hit and miss" or accidental sort of teaching. The information children gain under such conditions of teaching is likely to consist of isolated facts. In an effort to avoid this we have tried to organize our science around problems highly charged with interest to the child and which, at the same time, contribute toward an understanding of basic scientific concepts. In addition to this fundamental consideration, we utilize all the opportunities for science which arise incidentally. For not only is it the part of common sense to utilize to the full the needs that do arise, but it is also the part of common sense to *make* as many needs appear as you can manage. The source of the interest is relatively less important than the fact that there *is* an interest.

A science program based upon needs and interests is filled with vivid experiences and real experiences. There is nothing dull or formal about it even though the teacher is there in the background planning the activities and directing the work with respect to some end known only to her. This conception of science teaching shifts attention from things to meanings and understandings and it recognizes the value of simple generalizations for even the primary child.

One of the most important of the teacher's functions in teaching science in this way is to plan approaches that stimulate the children's interest in materials to be studied. The approach must develop a rich background of meaningful concepts that enlarge and deepen understanding and make it possible for the children to grasp the essential conditions of the problem. He is thereby enabled to define the problem sharply and also to ask specific questions about it.

Perhaps an example of how one such problem raising lesson was stimulated might serve to clarify what I have been saying.

Early in the summer we decided to try a unit on simple mechanics at first grade level. We were not sure it could be done with any degree of success, but were anxious to see what could be done. It offered a bit of a challenge to me for my knowledge of mechanics is decidedly limited! However, I set to work and outlined tentatively the major learnings or generalizations which I thought children should gain from such a study. Then I began placing books containing pictures about machines on the library table. I put pictures on the bulletin board to stimulate interest in machines. The children noticed these, commented on them, and began asking questions about them. Then one morning when the children came to school they found innumerable kinds of tools and machines scattered around the room. There were machines, simple ones to be sure, to illustrate principles of the wheel, of the wheel and axle, the lever, the inclined plane, and the pulley.

The children were permitted to play with these machines, to explore them, and to take them to pieces if they so desired. After a certain amount of this exploratory activity the children were gathered together and given an opportunity to ask questions. During this question raising period the teacher worked hard for six and seven year olds can ask a tremendous range of questions. How does one wheel turn another? How many wheels does a bicycle have and why aren't they all alike? Are two pulleys bet-

ter than one? How many pulleys will it take to lift forty tons of mercury? Does it make any difference where the weight is on the well sweep? (We have a model of a pioneer well showing a well sweep.) How can an inclined plane make work easier? These are just a few of the questions raised during this period.

All the questions asked during these periods were recorded by the teacher. In most cases the questions were recorded just as the children asked them. Occasionally it was necessary to help a child re-word his question so that it asked what he wanted it to. In a few instances it was necessary to question the child further to find out the real question behind the question he asked. After the questions were all raised, they were rearranged and organized into a logical teaching sequence. Sometimes this organizing is done as the questions are raised. At other times it is done entirely by the teacher.

When the questions were all recorded and organized the fun began—for these questions were all to be answered! Not in one day—not in one week—but in a unit of study which lasted several weeks.

The questions raised in this particular lesson were answered in one concentrated unit. That is, this unit was carried to completion before another unit was started. However, this is not true of all of our units. We teach a unit on the effects of seasonal change on plants and animals which is planned and organized as one unit but which is not all taught at one time. Different portions of it are taught at different times of the year. The parts of the unit dealing with seasonal changes taking place in fall and winter are taught in the fall and winter. The rest of the unit which deals with spring and summer is taught at the appropriate season. The teaching of the material in this unit appears almost to be incidental. In reality it is as thoroughly planned and organized as those units which are carried through to completion without interruption.

The questions raised by the children and which are organized into units of study are answered in different ways. Sometimes the teacher sends the children to a source. When a child wanted to know about the wheels on a bicycle, we brought a bicycle into the room and blocked it up so the rear wheel would spin freely. The children observed the wheels and noted how the sprocket wheels were cogged and how they were connected by a chain. They discovered that one sprocket wheel was larger than the other and that it made fewer revolutions than the smaller

one. They discovered that the rear wheel "pushed" and the front wheel merely guided and "went along" as it were. Another question, closely related to this one, was answered in a similar fashion. Mary had asked, "How does one wheel turn another." Our study of the bicycle had given us a partial answer to this question. We had seen that sometimes one wheel turns another by means of a chain. In order to show the children other ways in which one wheel will turn another we brought an egg beater into the room and the children saw how cogged wheels turn other wheels. We went down into the Home Economics room and looked at the wheels on the sewing machines and the children saw how a belt helps one wheel turn another. In answering both these questions the teacher's job was that of a guide. She directed attention by her questions and helped the children interpret their observations. However, the children really answered their own question through observation and exploration.

Sometimes in answering questions the teacher seeks the answer with the child. A definite "I don't know" spoken, not in tones of dismissal, but of "great-wonders-still-to-be-unfolded" tone is a greater stimulus to investigation than a meticulous explanation beyond the child's understanding.

When Jane asked "Does it make any difference where the weight is on the well sweep?" I simply said "I don't know—let's find out." So Jane got the well sweep, and we all sat down on the floor and worked together to discover that it does make a difference where the weight is placed on the lever. This particular question proved to be so interesting to the children that they were motivated to construct a small demountable see-saw in the room. They experimented with this until they had worked out, entirely alone, most of the important principles of the lever. They balanced blocks of equal weight on the lever, they balanced the lever with unequal weights by first moving the blocks used for weights and then by moving the fulcrum. Finally, one morning, as Joe sat looking at the lever, balancing with unequal weights on it, he suddenly shouted, "Miss Junge, come here, see what I can do." He proceeded to place all the blocks on one end of the lever and to balance it with a longer lever arm on the other side of the fulcrum. The children were so excited by this new discovery that they decided to see how long it would balance that way. It balanced for two weeks—until the end of the summer session. One day while the children were experimenting with the lever, a question arose as to whether or not a lever

could be used to lift things, and whether or not it made lifting things easier. Again the teacher's answer to this question was "Let's find out." We took five or six of our reading books and tied them together securely. We took turns lifting the books—with only one finger. Then we placed the same bundle of books on the window seat and tried lifting it with a lever, using only one finger on the lever. Here again the children discovered the answer to their question through direct experience.

Perhaps I should say that while the children were experimenting and discovering these laws governing the lever, we made no attempt to state them in any form. We were content just to have the children explore, discover and use their new found knowledge without tying it up into an abstract statement of fact.

The practice of answering a question with a question is probably extensively used by teachers who are eager for children to learn through first hand experience, rather than through second hand words. When Peter asked "How do wheels make work easier?", I asked him if he had ever tried to move a heavy box along the floor. We got a small wagon from the kindergarten room. We removed the wheels and loaded it heavily with books. Peter tried to move it. At first he was unsuccessful, but after much tugging he managed to drag it a short distance. Then we put the wheels back on the wagon and Peter again tried to pull the wagon. This time we had little difficulty in moving the loaded wagon. Thus Peter found the answer to his own question which he stated this way. "The box without wheels was hard to move. It sort of hung on to the floor when I pulled it. It scratched the floor, too. The box with wheels was easy to move—it rolled and rolled pretty fast when I pulled it. Wheels have a way of moving things easier."

I recall rather clearly another instance where we used this technique of answering a question with a question. The question was one which had arisen incidentally in connection with our school garden. We had been preparing the garden for planting. While we were working in the garden the children had found several earthworms and we had taken them into the first grade room. The children were anxious to find out more about the worms and one of the questions they asked was, "How does a worm walk?" The teacher's answer was, "Have you ever watched a worm walk?" In response to the loud "No" of the children, the teacher took the worms, placed them on a large sheet of

paper on the floor and we all sat down on the floor to watch the worms "walk." We watched them move across the paper and noted the way they moved. Then we got a large reading glass and looked at the worms more closely. The children were able to see the short bristles which helped the worm to move. They summarized their findings in the following sentences which they dictated to the teacher. "The worm has a way of walking. He humps himself up and then flattens himself out in a wiggling kind of way. He has bristles that help him walk."

In either case, I couldn't possibly have given better answers; although they might have been more scientific, they would have lacked the vividness of the children's descriptions.

Sometimes the answers to questions are best found through excursions. We do not limit our observational work to that which can be carried on in the classroom. In order to answer the question "How do pulleys make work easier," we took a short trip to a college building where some repair work was under way. We watched to see how pulleys helped in lifting and moving heavy timbers. When we returned to our room, the children rigged up a set of double wheeled pulleys and experimented by first lifting a load of books with one hand and then lifting the same load by means of pulleys, using only one hand on the pulley rope.

Occasionally questions are asked by the children which cannot be easily answered by observation or exploration. In cases like this we plan demonstrations which will answer the questions. It is possible sometimes to have the children help plan these demonstrations. At other times they are entirely teacher planned and teacher executed.

One such instance arose because it was John's responsibility to feed the goldfish. One morning, as he was feeding them, he turned to me and asked, "How can the goldfish live in the water all the time? How do they get air?" I could have answered this question by simply saying, "There is air in the water, John." However, it seemed to be a better procedure to show John that there was air in water. In order to do this we placed an inverted glass funnel in a beaker, covered the open end of the funnel with a test tube and filled the whole thing with water. Then we placed the beaker over a gas burner. As the water heated the children were able to see the bubbles of air moving up inside the funnel into the test tube. The air collected in the top of the tube and gradually forced the water out. This demonstration gave a clear and concrete answer to John's question. He didn't have to ac-

cept my word for the fact that there was air in water—he could see it for himself. This is an example of a demonstration completely planned by the teacher. As I indicated before our demonstrations are not all carried on in this way. Sometimes the teacher and the children work together in planning such an activity. A case in point was the planting of tomato and petunia seeds in flats. The children wanted to raise their own tomato and petunia plants to put in their garden. They discussed how it should be done and finally decided they needed the advice of some one more expert than themselves. They selected four children to go with the teacher to the head gardener in the University Plant House. These children consulted with the gardener as to how to prepare the flats, how to mix the soil and how to plant the seeds. They then reported back to the first grade and together with the teacher guided the rest of the children in preparing the flats for planting and in actually planting the seeds. The children all profited much from this cooperative demonstration.

During the course of a unit when we are answering pupil questions we come together very frequently to relate and discuss discoveries we have made. These discussions are apt to be lively, for the children feel entirely at ease and free to express their opinions. The children are encouraged to question and check statements made and many arguments arise.

The children defend their points by demonstrating how they have gained their information, by showing pictures, by reading from easy science books, or they frequently resort to diagramming on the blackboard. I recall one particularly hot argument between three boys. They were arguing about the particular use of an inclined plane. Finally George went to the blackboard and began making clear, straight line drawings to illustrate his point. When he had finished he turned around and shook the chalk at me and said, "Miss Junge, I would hate to have Joe think that the inclined plane is used as he says it is. Now this is the way it is used." And he proceeded to explain his diagrams very clearly. It so happened that George was correct in his explanation.

Our discussion periods serve to clarify and to tie together the facts discovered through reading, observation and exploration. They also serve as a means of stimulating new questioning and new ideas.

It is no doubt evident from what has been said that the teach-

er's part in answering the children's questions is not an easy one. It is up to her to act as a guide, to be curious enough, and alert enough, and interested enough to help the child discover the truths for which he is searching. She must keep in mind that these children with insatiable curiosities are not storehouses to be stocked with information filed under conventional headings, but rather that each child is a one man expeditionary force exploring, probing, examining, and questioning his environment.

She will need to organize the science program around challenging problems which develop essential meanings and then to direct these meanings toward the understanding of fundamental concepts of science. She will need to utilize the children's interests in planning her program, but at the same time will have to arrange for the systematic presentation of her material in organized, pre-arranged units.

It is no doubt evident from what has been said that the procedures used in presenting science in this program differ quite markedly from the reading-recitation method used by many teachers of primary science. The children do not gain their information just by reading or being told by the teacher. Their understandings are gained

1. through excursions into the school yard and neighborhood,
2. through bringing plants, animals and inanimate objects into the schoolroom for observation,
3. through handling various materials,
4. through experimenting and exploring,
5. through demonstrations and directed observations, and
6. through discussions in which all participate.

Science taught in this way provides for the maximum of child experiencing and child participation. Learning is an active process and one of vivid, real experiences. It makes the child better able to think clearly and to face reality without fear and confusion. This is especially important in a world as unsettled as ours. No one knows what a child will have to face as an adult. All we can do is to train him to keep his mind open to the idea of change. He must learn to collect data, to weigh it, and to draw as accurate conclusions as possible from it. If we can give a child these habits, then we will have given him a firm foundation upon which to base his thinking and a scientific way of solving any problem with which he is faced.

A COMPARATIVE PERFORMANCE OF HIGH SCHOOL AND UNIVERSITY FRESHMEN ON A TEST OF BIOLOGICAL MISCONCEPTIONS

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In statements of teaching objectives, biology teachers usually assign a prominent place to the elimination of superstitions and misconceptions from the minds of students. The following excerpts from texts and syllabi in the field of general biology suggest that this is true.

"To free the students' minds from various errors and misapprehensions."

"The (elimination of) common prejudices in the field of health and disease."

"The development of a trait of skepticism as opposed to credulity."

"Science training should eliminate superstitions."

"Train the individual to base judgments on fact and not on prejudice and superstitution."

"A direct attack is made upon superstitions."

"Abolition of fears and superstitions by recognizing truth and applying it to life situations—disease, prenatal effects, ghosts."

Most of the texts in general biology index such topics as "superstitions," "patent medicines," "weird healing practices," "medical fakers," and "false advertising," which indicate that biology teachers are concerned with the problem of misconceptions and superstitions.

In order to develop in students a critical attitude, it is helpful for the instructor to know the nature of his students' beliefs about biological phenomena. One way of discovering these beliefs is to use a test or an inventory. For this purpose in introductory courses in biology, the writers have been using a test of biological misconceptions. Parts of the test have been used in retest studies to determine the effectiveness of a university course in attaining the objective in question. The present study reports a comparison between the performance on this test of 65 students entering the University of Illinois, September 1942, and that of 100 students entering Greenville High School,

Greenville, Illinois, also in September 1942. The comparison, therefore, is one between university freshmen and high school freshmen.

The test was developed at the University of Illinois for use in a course in general biology which is offered by the General Division of the College of Liberal Arts and Sciences. In this course, which is a full-year survey of biological science, considerable effort is expended upon the cultivation of scientific attitudes and skills. In this connection, the instructors give some attention to popular misconceptions. The test has been revised twice and in its last form consists of 125 items each in the form of a statement dealing with a biological belief. Approximately 35 items relate to beliefs about health, disease, and nutrition; 25 items concern the behavior of animals including domestic animals, birds, insects, and snakes; 13 items present notions relating to psychic phenomena, and the like; the remainder of the test is comprised of statements about miscellaneous biological phenomena. Perhaps the nature of the test can best be indicated by including a few representative statements. In the directions the student is asked to record whether he thinks a statement true, probably true, probably false, or false, and he is instructed to make no response if he has no opinion.

T	PT	PF	F	The inherited characteristics of a child are determined at the beginning of pregnancy.
T	PT	PF	F	After death the hair and nails continue to grow.
T	PT	PF	F	A century plant flowers once in a hundred years.
T	PT	PF	F	If a silver coin placed upon a mushroom turns black, the mushroom is poisonous.
T	PT	PF	F	Hereditary characteristics are carried by the blood.
T	PT	PF	F	An abundant crop of acorns signifies a cold winter.
T	PT	PF	F	Bats like to become entangled in human hair.
T	PT	PF	F	If you think hard of some one a long way from you, he will know it.
T	PT	PF	F	When grubs appear in stale meal or flour, they have arisen from the dust of the grain, not from eggs.
T	PT	PF	F	Men have one less rib than women.

Scoring is done in terms of degree of belief. By offering several responses to each statement, the test is believed to provide for the recording of partially fixed beliefs which the student might hesitate to call either absolutely true or false. Scores of 3, 2, 1, and 0 are assigned to responses depending upon the degree of credulity or superstitiousness which the student possesses. Thus, the higher the score, the more credulous is the student. Statements to which the student does not respond are ignored in the scoring. Students omit very few. Each statement appears in a

form which several biologists have agreed is correctly answerable as either true or false. Used with university freshmen, the test yielded a reliability coefficient of .92 computed by use of the Spearman-Brown Formula.

The performance of the two groups of freshmen—high school and university—is summarized in the table. The difference of 26.31 between mean scores easily meets any of the commonly used criteria of statistical significance.

Performance on a Test of Biological Misconceptions

	Number	Mean	Standard Deviation	Difference	Standard Error of Difference
University freshmen	63	76.84	31.99	26.31	5.2
High School freshmen	100	103.15	36.22		

A number of factors, of course, would favor the university group in a comparison of this kind. Sixty per cent of the university freshmen had had a course in high school biology and 80% had had general science. The high school freshmen, on the other hand, had studied biological science only in the elementary grades. It is probable that the university group was more highly selected with respect to such factors as intelligence and economic status since there is evidence to indicate that this would be true in such a comparison. Both intelligence and economic background presumably may be reflected in the score made on this test. In the present instance it was impossible to take intelligence into account except in the case of the university students who had been tested with the American Council on Education Psychological Examination. The mean scores on the ACE Psychological Examination were computed for the university students who scored above the mean on the biology test and also for those scoring below. The group scoring above the mean on the biology test averaged 103.0 on the ACE Test. The average ACE score of the group scoring below the mean was 105.4. The difference between mean scores on the ACE was of no significance.

The question of sex differences was investigated. In the university group the mean score for girls was 81.3, whereas the mean score for boys was 73.1. The difference of 8.2 is barely statistically significant. In the high school group the difference between mean scores of boys and girls was smaller.

In order to determine whether living in a rural environment, as compared with urban life, influences performance on the test, the scores of 33 of the high school pupils living on farms were compared with those of 28 pupils residing in town. The farm group was slightly, though not significantly, more superstitious, the mean scores being 105 and 97 respectively.

These results are fairly closely in accord with those obtained by others who have studied the beliefs of students. Garrett and Fisher[1] compared high school seniors with college students in their beliefs about certain psychological notions and found the high school students more credulous. No relationship existed between intelligence and credulity.

It appears that superstitions and misconceptions are to be found everywhere. Certain ones, however, seem to be localized in particular geographical regions which suggests that the biology teacher who intends to attack the problem of false beliefs ought first to survey the beliefs which his students hold. There is reason to believe that the study of misconceptions can provide a valuable means of learning the scientific attitude.

[1] Garrett, H. E., and Fisher, T. R., "The Prevalence of Certain Popular Misconceptions." *Journal of Applied Psychology*, 1926, X, pp. 411–421.

TEACHERS' SALARIES

Forty teachers in every 100—about 360,000—are being paid less than $1200 for the school year 1942–43. Nearly 8 in every 100—68,000 in all—are being paid less than $600 for the present school year.

Low salaries for teachers are typical in the Southern states but they are by no means limited to that region. At least 169,000 of the teachers receiving less than $1200 a year are outside of the Southeastern and Southwestern states; 15,000 receiving less than $600 a year are likewise in states other than the Southern states.

There are about 61,000 Negro teachers in Southeastern and Southwestern states where schools are segregated and salaries differentiated. About 53,000 of these Negro teachers are paid less than $1200 per year; about 30,000 are paid less than $600 a year.

Only 2 of the 48 states (and the District of Columbia) report that no teachers are being paid less than $1200 for 1942–43. Nearly 15,000 teachers in Pennsylvania, 23 per cent, are paid less than $1200. The percentage is even high in Illinois, where about 30 per cent, or some 14,000 teachers, receive less than $1200.

Twenty-six of the 48 states employ teachers at less than $600 a year. In Mississippi and Arkansas half or more than half of the entire teaching staff is being paid less than $600 a year. In Maine, every sixth teacher is paid less than $600. In South Dakota, employing only 8000 teachers, some 1600 are paid less than $600. More than 4500 teachers in Kansas—one in five for the state—receive less than $600 for the year's work.

SCIENCE EQUIPMENT—"FOR RENT"

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One of the major science teaching problems in our high schools and small colleges is that of providing optimum science equipment for the budget allowed. The teacher is constantly confronted with the problem of choosing the best way of spending his allotment. In many instances, if not in most, he must decide against the costly items knowing that they will probably be used by fewer students and on fewer occasions than the common, inexpensive items.

Last year, this writer suggested a possible solution to this problem by proposing that some central agency rent equipment to schools for the length of time that the apparatus is needed. The longer this solution was considered, the more potential possibilities it appeared to have. Most teachers have either taught in schools or visited classrooms in which a set of atomic models and crystal models would be too expensive to warrant their purchase for the more or less limited use they would receive. Many of these same schools could during the year make excellent use of astronomical models, telescope, static machine, cross sectional models of automotive parts, biological specimens, anatomical models, botanical collections, geological exhibits, radio transmitter, etc., but the initial price of each item is high and such a purchase might mean tying up relatively large amounts of money for equipment that will not be used very often. Some people might imagine that the excellent sound films and other visual aids take the place of these laboratory devices, but most science teachers will agree that there is nothing which can completely take the place of actual equipment and its manipulation. It is not necessary to debate here the merits of visual education. It is only necessary to say that some movies are a valuable addition to any experiment or demonstration.

After talking this plan over with a number of teachers, this writer wrote to several of the large scientific supply houses inquiring if they had ever considered rendering such a service to the schools. One or two of the companies were rather discouraging but the majority of them showed a definite interest in such a project. They felt that they needed an expression of opinion from the schools so that they would know how many would be interested in subscribing to the service and whether each would

be willing to assume the responsibilities associated with such a project. For example, any cooperating or subscribing school would have to be willing to pay for any damage to the materials and to use extreme caution in handling the equipment.

In order to ascertain whether this plan appealed to teachers generally or whether its merit was seen only by a few, this writer incorporated some questions concerning this plan into a questionnaire distributed in the spring of 1942 to a stratified sampling of schools in Minnesota. This sampling was selected on the basis of the secondary schools located in 609 localities exclusive of the first class districts in Minneapolis, St. Paul, and Duluth. The stratification was done on the basis of enrollment and type of school: (1) Junior High School, (2) Three Year High School, (3) Four Year High School, (4) Six Year High School, and (5) Other Type Secondary Schools. The returns from the questionnaire were tested for adequacy of sampling by employing the Chi Square technique on the stratified array. This test did not refute or even cast suspicion on the "null hypothesis" namely: that the returned sample was representative of the population originally chosen. In other words, one can interpret the data as being fairly representative of the secondary schools in Minnesota exclusive of the first class districts.

In view of the fact that the three comments relative to "rental apparatus" comprised a very small part of the questionnaire, it is doubtful if justice was really done to the project and its possibilities. The three questions were limited to the following comment:

> "9. Do you wish us to request the scientific supply houses to rent various pieces of equipment to schools so the budget would reach further and so that there would be less money tied up in expensive equipment which is used once or twice a year?_____. Would your school make use of such a service?_____. Would your school be willing to pay for damage or breakage?_____."

About twenty-four per cent of those who returned questionnaires neglected to answer this item and this might or might not be interpreted as a negative response. Of those who did reply, about seventy per cent definitely wished the scientific supply houses to be approached on the subject and another five per cent were somewhat in doubt. The remaining few definitely placed themselves on record as disliking the plan.

Practically all who wished the supply houses to be approached, or in other words about sixty-six per cent of those answering the item, put themselves on record as wishing to subscribe to such a service and willing to be responsible for the equipment while in their hands.

In view of the fact that this suggestion pertaining to the rental and distribution of scientific laboratory and demonstration equipment may be new to many and considering that this questionnaire did not attempt to explain the proposal fully, the responses seem to indicate that most of the teachers would welcome such a service. Some will say that this is not the time to consider such a proposal but that it might possibly serve a useful purpose after the war. Perhaps that feeling may account for some of the negatives or for some of the failures to respond to this part of the questionnaire. However, during this rebirth of the sciences in our schools today, one certainly has an opportunity to see just what equipment has been neglected. During this emergency, during the time when so much emphasis is being placed upon helping the students master scientific principles, one needs to consider how the schools might offer better laboratory and demonstration facilities. Everyone realizes that science will continue on an upward trend after the war and that of course means that the need for science equipment in schools will not decline, but instead will continue to grow.

One may wonder just how such a "rental" scheme could be set up so that it would be efficient and workable. These are things which the agency itself would have to decide upon and it would have to determine such things as: (1) number of schools to be served; (2) kinds of materials desired; (3) length of time needed for using each piece of equipment; (4) degree to which the season affects need and usefulness of equipment; (5) maintenance cost of equipment; and other such considerations.

The distribution of materials would also be a problem for consideration. Materials for the whole middle west could not be distributed from any one point but it would be necessary to have several distributing and servicing centers. Perhaps a distribution point would be needed in each state and in some cases perhaps several in a state depending upon how many schools were to be served. Some colleges or universities might be willing to undertake the scheduling of these exhibits and pieces of equipment and they might also be willing to service them and handle the shipping. For the state institutions, this would be a worth-while

service to perform whether they owned the equipment or whether they were merely acting in this capacity as distributors and aids for the scientific supply houses.

Probably many will have suggestions to make regarding such a plan as has been described in this paper and some of these suggestions might easily head off later difficulties and confusion. This writer would appreciate hearing from those who have criticism regardless of whether it is constructive or merely destructive. In case this project is really feasible, progress toward locating the proper cooperating agencies should be made without delay and if it has little or no merit, it would be well to halt the proposal before time, expense, and effort are wasted.

WEEDS GO TO WORK TO HELP WIN WAR METALS ANNOUNCED

The Ninth Annual Chemurgic Conference meeting here heard from two Chicago pioneers in getting uses out of plants generally considered useless —milkweed and cattail.

Milkweed floss, used in lifebelts and floats to replace kapok from lost overseas sources, is being separated from its seeds in a factory here by Dr. Boris Berkman, who was a military surgeon in the Russian army during the first World War. Last year's crop amounts to 50,000 pounds of the silky, white stauff—a veritable mountain of floss. The U. S. Government has taken every pound that could be supplied, and has contracted with Dr. Berkman for a great deal more.

Practically all of the milkweed pods thus far used in Dr. Berkamn's factory come from a large tract of cutover timber land in northern Michigan, where the sandy soil is so poor that it cannot be cultivated. Farmers in the neighborhood last summer found picking milkweed pods a good source of cash income—their earnings ran between four and seven dollars a day.

Dr. Berkman has found a ready market for the milkweed seed from which a high quality oil can be extracted. It resembles soybean oil in its properties and possible uses. He also expects to get other byproducts from pod shells and stalks.

Cattails are the other weeds that have gone to work. Their story was presented by Dr. C. F. Burgess, who is president of a large storage battery concern. Cattail floss, though different in appearance from milkweed floss, has much the same uses: lifebelts and floats, heat and sound insulation, filling for cushions and so on. Cattails grow in swamps and on pond margins all over the country, and their heads or spikes are hand-harvested as a part-time occupation by country lads, boy scouts and anybody else who wants to make a little extra cash. Dr. Burgess stated that on a cost per pound basis the material can compete with cotton.

One valuable feature about the cattail harvest is that it can be continued through almost the entire year. In the north, the heads are ripe in August, and stay on the plants through most of the winter. Then southern cattails come in, permitting an almost continuous flow of material to the processing plant.

NOTES FROM A MATHEMATICS CLASSROOM

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(*Continued from the April issue*)

48. A Test for Bright Pupils. We do not practice homogeneous grouping at Hyde Park but sometimes, by accident, I have had a class in ninth grade algebra whose intelligence is above the average. In such classes there is always keen competition among the leaders, and all the pupils have decided opinions as to who is the best. As the devotees of basketball cry for games to settle the championship, so the class cries for tests to decide who is the champion in algebra. In attempts to settle the question I have used the following test near the end of the year.

I state in advance that the problems will be such that a bright pupil will find some short and simple solutions while a not-so-bright pupil will get so tangled in details that he cannot finish many problems. The problems may be familiar ones dressed in new language or may involve topics that have not been studied to see how quickly a pupil can learn. Each pupil brings to class two sheets of $8\frac{1}{2}$ by 11 paper, each side divided into 8 sections (two columns of four each) numbered 1 to 32. The work for each problem must be done in the proper section to facilitate my work of grading the papers. A pupil may guess an answer, if he wishes, and may work the problems in any order.

To add interest to the competition I ask each pupil to make a prediction of how the best pupils will rank. These predictions (with one of my own) are written, collected, sealed in an envelope, and will be opened the next day.

Here are the problems:

1. Solve $3\frac{1}{7}(x+3)^2=9\pi x^2$

The bright pupil will notice that $3\frac{1}{7}$ is π. Hence he divides by π. Then he does not square $(x+3)$, but finds the square root of both members. Hence $x+3=3x$. If he tries to be too brilliant and uses $-3x$ as well as $+3x$, then he gets only half credit on the problem. This is evidently a problem about areas and the radius cannot be negative.

2. Simplify the expression $\dfrac{b-a}{a-b}-\dfrac{2a+2b}{a+b}$.

The first fraction equals -1; the second equals -2. The rote learner loses time by finding a common denominator, etc.

3. Which is the best way to write $3b^2+a^2-4ab$ if you wish to divide it by $(a-3b)$.

Ans. $(a-3b)(a-b)$. A wrong answer is $a^2-4ab+3b^2$.

4. $5(2+\sqrt{3})(2-\sqrt{3})=?$

5. Guess a solution of $xy=-60$, $x+y=28$.

This problem tests merely ability to handle negative numbers quickly.

6. Solve for x: $(a-b)(b-c)(c-a)=x(c-b)(c-a)$.

7. If $y=5x$ what do you get when you divide x by y?

8. Solve: $$\frac{1}{15}=\frac{x+1}{60}$$

The bright pupil thinks: $1/15=4/60$. Hence $x+1=4$. All pupils will solve this simple equation, but the bright pupil can do it more quickly, and thus solve more problems.

9. John is r times as old as Henry. Next year John will be s times as old as Henry. Which of these pairs of numbers cannot be used for r and s in this problem:

(a) $r=5$, $s=4$ (b) $r=10$, $s=12$ (c) $r=3$, $s=3$

The bright pupil knows from experience that s is smaller than r. Other pupils lose time by experimenting.

10. Data: $y=6x$, $w=2y$, $r=30w$, $t=45r$, and $w=253.4$. Which is larger, t or w?

Some pupils do the arithmetic; others see that $t=45\times30w$. Sometimes a super-bright pupil will add "provided the numbers are positive." He is given a bonus of 1 point.

11. Divide $(a+b)(c-d)+(a-b)(c-d)$ by $c-d$.

12. If $x+y=10$ and $x-y=2$, what does x/y equal?

13. What is the difference between the solutions of $6x=48$ and $10=2w$? Ans: 3. This is, of course, a "catch."

14. $\sqrt{1+\frac{2}{a}+\frac{1}{a^2}}=?$

15. If $y=3x+4$ and $w=5x+9$ and x increases from 10 to 20, which increases faster y or w?

Some pupils examine the coefficients in the equations, and some pupils make a table of values for y and w.

16. Would the point $x=39$, $y=7$ be on or off the graph of the equation $50x-125y=25$?

Some pupils will guess; some will substitute the numbers; some will change the equation to $2x-5y=1$, and see at once that 39 is too large a number for x if y is 7.

17. Which of these are wrong: (a) $\sqrt{x^2+y^2}=x+y$ (b) $\sqrt{x^2-y^2}=x-y$ (c) $\sqrt{y^2-x^2}=(y-x)(y+x)$

A pupil may score $\frac{1}{3}$, $\frac{2}{3}$, or 1 point according to how he answers. These fractional points are useful in avoiding tie scores.

18. Find x if $\sqrt{32}+\sqrt{2}=\sqrt{x}$.

This type of problem has not been studied, but a bright pupil will write the left member as $4\sqrt{2}+\sqrt{2}=5\sqrt{2}$ or $\sqrt{50}$. Hence he sees that x is 50.

19. John can make a model plane in 2 hr. 10 min. Henry is twice as efficient. How many can Henry make in 13 hr.?

The follow-the-rules pupil will try to use x and an equation. The bright pupil divides 13 hr. by 1 hr. 5 min.

20. If r is greater than 10, which of these fractions is largest:

$$\text{(a) } \frac{60}{2r} \qquad \text{(b) } \frac{20}{r-2} \qquad \text{(c) } \frac{30}{r-2}$$

21. Write the equation for finding the altitude of an equilateral triangle whose side is a.

22. If $a=b+c$ $r=b-c$ $s=a-r$ find s if $c=10$.

23. Simplify:

$$\frac{\frac{2}{a}+\frac{4}{b}-\frac{3}{b}-\frac{2}{a}}{\frac{3}{b}+\frac{1}{a}-\frac{2}{b}-\frac{1}{a}}$$

24. If $x^2=16$ then $x^3=?$

Many pupils will forget that x may be -4 as well as $+4$.

25. x^{-3} means $1/x^3$. Find x if $x^{-3}=1/8$.

Negative exponents have not been studied; hence this is a test to see how quickly a pupil can learn something new.

26. Write $a^2-b^2-2bc-c^2$ as the difference of two squares.

27. If $x^2+x=1000$ which of these numbers is the best guess for x: 28, 29, 30, 31, 32, 33?

The bright pupil tries 30 first; then 32. Ans.: 31.

28. Why could 469 not be the square root of 239,657?

Ans.: Because 9×9 does not end in the figure 7.

29. If $3x-2y=6$ what is the rate of increase of y.

30. The sum of two numbers is s; their difference is d. What does the difference of the squares of the numbers equal?

31. Why would $s=n(50-s)r$ be a useless formula for s?
Ans.: Because s appears in both members.

32. Find the value of

$$30\times\frac{5}{13}+29\times\frac{8}{13}$$

Most pupils do the arithmetic, but a bright pupil thinks:

$$30\times\frac{5}{13}+29\left(1-\frac{5}{13}\right)=29+\frac{5}{13}=29\ \frac{5}{13}$$

or,

$$30\left(1-\frac{8}{13}\right)+29\times\frac{8}{13}=30-\frac{8}{13}=29\ \frac{5}{13}.$$

The best score ever made in 40 minutes has been 29.

On consulting the pupils' predictions we usually find that they can correctly select the top four or five leaders although the order may not be right. As one might expect, the pupils are not able to distinguish between the pupil (a) who does well through conscientious and regular work, and the pupil (b) who does not have a consistently excellent record but who can think well when confronted with a new and unusual situation. Usually it is the second type who makes the better score on this test.

The following are some other problems which I have used on similar tests:

33. The numerator of a fraction is multiplied by 12 and the denominator divided by 6. Has the value of the fraction (a) been doubled (b) made half as large (c) made 72 times as large (d) been divided by 72?

34. If you drive 10 mi. at 30 mi. an hr., and then 20 mi. at 40 mi. an hr., what has been the average speed for the whole distance?

35. The product of two numbers is p; one of the numbers is n. What is the sum of the numbers?

36. John can do his homework in 15 min. Henry needs 20 min. to do the same work. They start at the same time. What part of Henry's work is unfinished after John has worked 12 min.?

37. Write $100h+10t+u$ so that it will be 9 times a trinomial plus some other quantity.

38. Jones can drill 40 rivet holes in 2 hr. Smith is ten per cent more efficient. How many holes can Smith drill in half an hour?

THE FORMS AND USES OF GRAPHITE

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Graphite, whether in the natural state or a product of the electric furnace, is probably one of the most useful materials.

The following remarks are intended to outline the historical development of this substance and aid readers in distinguishing between the numerous varieties available.

GRAPHITE'S HISTORY

The earliest use of graphite (plumbago, black lead; deriving from the Greek word meaning "I write") has been traced to the decoration of stone vessels by the ancients. Unknown for some years, it re-appeared during the Middle Ages as a curiosity, probably confused with molydenite, a similar appearing substance. English farmers, however, found graphite particularly useful for marking cattle, alchemists employed it as crucibles for melting precious metals, and Italian artists, somewhat later, spoke highly of its use in drawing.

With the discovery of rich graphite mines in England around 1564 and subsequent exportation of the mineral, the marking properties of "Flander's Stone" as it was called by Flemish dealers became widely known. Writers depicting 16th century life mention the use of styli comprising this mineral sharpened to a point and inserted in a wooden handle. Excavated debris from British military encampments of the American Revolution often contained similar mineral "strips"; it is likely that the aborigines of this country were well acquainted with graphite's ability to mark smooth surfaces.

Early chemists, nevertheless, continued to make no distinction between graphite and molybdenite, and it was left for the German chemist Pott (1692–1777) to prove the absence of lead in graphite. His experiment automatically demonstrated that the nomenclature "lead or black lead," which persists even today, is erroneous. Lead pencils are more correctly "graphite pencils."

It was not until 1779 that Karl Scheele established graphite as an elementary substance, a kind of mineral carbon. Thirty years elapsed, however, before graphite was officially included in the carbon family. The mineralogist, A. G. Wener (1750–1817), is accredited with coining the word "graphite" to ex-

press softness, unctuousness and ability to mark or decorate surfaces.

From this date forward many deposits of natural graphite were found and developed throughout the world, notably in Austria, Bavaria, Ceylon, England, Siberia and the United States. Some of the deposits were of such purity as to allow immediate cutting into strips for pencil manufacture, while others were so inferior as to be useful only for the coloring of fertilizers. Its use in refractories, lubricants and dry batteries materialized as technology grew.

In 1896 Edward G. Acheson discovered a process whereby ordinary carbon could be converted into graphite by the use of high temperatures. This man-made graphite immediately found application in the electrochemical industry, making many electrolytic and electrothermal processes possible. Further experimentation followed until in 1906 Acheson produced an electric-furnace product superior in many respects to graphites taken from the earth.

This material readily lent itself to a colloidalizing or subdividing process devised at about the same time by Acheson. He found that individual graphite particles could be suspended in water and oil carriers for long periods of time. These graphite colloids, as they were subsequently showed to be, greatly enhanced the utility of the graphite. Soon the successful drawing of tungsten for lamp filaments and the lubrication of devices operating at high temperature became standard procedures.

As the stability of the dispersions was improved with continued research, the number and kinds of carriers were increased over the original water and oil. In recent years the deep penetrating and fast evaporating properties of such liquids as mineral spirits and kerosene have been employed as vehicles for the graphite, much to industry's advantage.

Today the graphite business, which includes the producers of both the natural and electric-furnace types, is indispensable, supplying products of an exceedingly wide and varied range of usefulness.

Forms of Graphite

Graphite like the diamond and charcoal consists of carbon. It is characterized by softness, a grease-like feeling and gray metallic luster.

Pure graphite is insoluble as well as nonfusible; it is highly refractory, although combustible. It is extremely inert, being

chemically affected only by the most extreme of oxidizing agents. Its equivalent in softness and smoothness is unique among all solid substances (hardness by Moh's scale equals one). It possesses a specific gravity 2.1–2.3 intermediate between the other allotropic forms of carbon. (Charcoal: 1.1–1.9; diamond: 3.5.)

Where charcoal leaves a dull black mark on paper, graphite makes a line of grey-black sheen and diamond none whatever. Charcoal, cut with a knife, is brittle; graphite, grease-like; while diamond is unscathed by the hardest file. Diamond and charcoal are poor conductors of electricity and heat, but graphite is comparable with metals in this respect.

Natural: Graphite commonly occurs in foliated, columnar, slaty, and dense earthy deposits having a dull coal-like gloss. It exists in two forms in nature: the foliated or crystalline variety, which is in flakes; and the amorphous or non-structural type having a compact and earthy texture.

Crystalline graphite of the vein type is found in both pockets and strata, requiring hand-mining methods, while the flake variety occurs as scaly particles in schists and limestones, necessitating mechanical concentration methods. The amorphous grades occur as metamorphosed coal seams, highly carbonaceous shales or asphaltic beds rich in graphite content.

The flake variety is exactly as the name implies. It consists of numerous flat planes which slide one over another in much the same manner that cards in a playing deck do when subjected to tangential pressure. These characteristic lamellar plates remain even after mechanical pulverizing. Amorphous graphite, however, lacks such definite appearance to the eye, being quite formless, grit-free, and soft.

The commercial uses for these forms are interesting. The better qualities of crystalline graphite both vein and flake, for example, are employed chiefly in the manufacture of crucibles, retorts, muffles, stirrers and other articles designed to withstand high temperatures. Mixed with clay and sand and later fired, graphite imparts a resistance to sudden heat changes and a degree of heat conduction unequaled by most metals. Flake graphite is also used in the manufacture of electric dry cells.

Its minute plates of extreme thinness and flexibility are likewise added to lubricating oils, greases and in some cases water, to decrease friction in heavy machinery. The dust and smaller particles resulting from the refining of the costlier forms are

normally used for this purpose. Other applications of a minor sort include the compounding of stove polishes, boiler cements, scale preventatives, and belt and cable dressings.

Amorphous graphite as found in a nearly pure state in a few deposits, combines readily with clays making a satisfactory mixture for pencil manufacture. When ground into linseed oil with a certain percentage of silica, it produces an elastic yet hard protecting film used largely in coating steel structures. As a foundry facing, it prevents the sand from which the moulds are composed from adhering to the metals being cast thereby producing smoother castings which require a minimum of machining.

All of the foregoing uses demonstrate the importance of natural graphite.

Electric-Furnace, Powdered: Carbon reduced by extreme heat to graphite in an electric-furnace, is powdery in form and known as the manufactured variety. This man-made product is neither an imitation nor a substitute for the natural material. It is actually crystalline graphite.

Where even the rarest of mined deposits must undergo some dressing before use, manufactured graphite is prepared almost wholly devoid of impurities. The careful selection of raw materials and an extreme volatilizing treatment assures this. Besides unusual purity, graphite of this type is more refractory than the mined product, having resistance to oxidation in air which is proportional to the temperature of formation.

The inherent superiority of manufactured graphite over the natural substance is best revealed by the kind and variety of its commercial uses. For example, many electro-metallurgical and electro-chemical processes are highly dependent on electrodes prepared from man-made graphite. Thus chlorine and caustic soda are two notable substances owing their production to either die-extruded or pressure moulded masses of carbon subjected to electric-furnace treatment. The self-lubricating, electrical conducting, and heat resisting properties of certain commutator brushes, pastes, linings, and blocks are also due to this type of graphite. When blended with grease and employed in innumerable lubrication problems, the pure, unctuous particles equalize the irregularities of metal surfaces and form a load-sustaining, heat resisting film of low friction properties. It is likewise employed in dry battery construction and for electro-typing methods.

Electric-Furnace, Colloidal: The word "colloidal" connotes particle sizes approaching those of solids in true solution. Colloidal graphite is pure, electric-furnace graphite in such a condition. Thirty-three of its "average" particles, one above another, span a distance of approximately one ten-thousandth of an inch (1/10,000 in.), while the finest lie well between 1 micron (0.00003937 in.) and submicroscopic dimensions. Minute sizes of these orders permit the dispersal of graphite particles in liquids where they remain suspended indeterminately. Like electrical charges borne by the particles facilitate this and prevent inter-collision and agglomeration.

When viewed in the ultra-microscope such colloidalized solids exhibit intense three-dimensional (Brownian) movement, punctuated with occasional scintillations. The latter are explained by light reflections from the flat faces of graphite crystals which X-ray examination reveal are composed of atomic planes lying parallel with one another. These sheets, however, do not lie symmetrically adjacent but correspond alternately, thereby giving rise to free slippage so useful in lubrication.

TABLE I

PHYSICAL AND CHEMICAL PROPERTIES OF COLLOIDAL GRAPHITE

Unctuous, dry lubricating solid
Relatively good conductor of electricity
Resistant to high temperatures
Co-dispersible with many liquids and solids
Anticorrosive agent
Truly colloidal dimensions
Chemically inert
Practically pure
Opaque
Relatively good conductor of heat
Resistance compound
Low in photoelectric sensitivity
Low coefficient of expansion
Gas absorbent
A "black body"
Diamagnetic
Specific gravity between 2.0 and 2.5
Moh's scale of hardness less than 1
Electrically charged particles

Besides these interesting characteristics, graphite particles in the colloidal state pass unhampered through extremely fine interstices: ordinary filtering will not separate them. Electrostatic fields, moreover, orient particles to mutually parallel posi-

tions, while in solution. More important, volatile carriers deposit the graphite particles onto surfaces in the form of homogeneous films possessing all the chemical and physical properties of the graphite itself (see Table I).

Of these, the excellent lubricating qualities of colloidal graphite films are most extensively employed. Four reasons account for this use: colloidal graphite (a) permits increased oil spread, (b) holds oil to itself, (c) affords dry lubrication and (d) resists high temperatures. Functioning together, these factors comprise a supplemental lubricant capable of meeting the most severe operating conditions, including both boundary and prolonged dry running. Many graphited-oil blends, accordingly, are prepared for industries such as spray, leaf, penetrating, upper cylinder, high temperature, rubber and special purpose lubricants. The series of concentrated dispersions available commercially (water, petroleum and castor oils, glycerine and mineral spirits) are diluted with appropriate amounts of their carrier before use in innumerable lubrication problems, ranging from locks to steam cylinders.

The unctuousness of colloidal graphite films also has special significance in the field of parting. For example, numerous metal, glass and plastic parts owe their fabrication by molding methods to this material. Dry films, unusually resistant to high temperature, produce stain and blemish-free objects without too frequent recoating of molds.

By means of the common techniques for impregnation and incorporation, colloidal graphite dispersions impart electrical conductivity, lubricity, opacity and heat resistance to porous bodies; thus asbestos packings, industrial soaps, non-fading rayons and electrical conducting papers are made possible.

Colloidal graphite films applied either by spraying or brushing, dry with sharp boundaries, adhere tenaciously and possess a matte-like finish. As good conductors of electricity they serve as focusing anodes, contacts, cements, resistance strips, and shields.

In addition to the foregoing applications of a major character, there are numerous miscellaneous uses utilizing the anti-corrosive, gas absorbing and heat conducting properties of graphite solids in liquid suspension. Thus boiler water is treated for scale; certain vacuum tubes and thermopiles are more conveniently fabricated. Actually colloidal graphite is presently involved in the commercial realization of over 250 applications.

Altogether the several forms of graphite discussed above constitute a sizable industrial enterprise involving numerous world-scattered plants and mines; millions of dollars in equipment and annual business.

AN ANALYSIS OF A PURPORTED TRISECTION OF AN ANGLE WITH RULER AND COMPASSES

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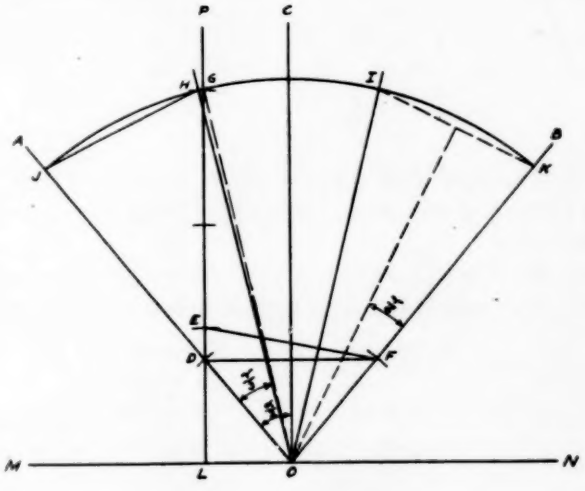
EDITOR'S NOTE: In a recent number of this Journal (No. 5, 1942) Robert Torkelson proposed the question "Is it at all possible to trisect *any* angle?" The interest aroused by this question prompted Mr. Schepler, whose hobby for many years has been to expose by analytic methods the fallacies of the so-called Euclidean trisections, to present the example below.

Individuals who are in possession of so-called Euclidean solutions, that is, solutions by ruler and compasses, whose accuracy is such that the error can not be detected in a careful drawing are invited to send these "solutions" to the editor together with analyses if such have been made. A few of the best solutions will be published. J. M. K.



SKINNER'S TRISECTION

A method of trisecting an angle, claimed to be a Euclidean solution, appeared in a midwestern newspaper in 1931.* It is as follows:

* In the Dubuque *Telegraph Herald*, Dubuque, Iowa, by Lon W. Skinner.

PROBLEM: To trisect angle AOB geometrically.
PROCEDURE:

(1) Construct bisector CO of angle AOB, and MN perpendicular to it.
(2) With O as center using any radius, strike an arc cutting sides of angle at points D and F.
(3) Through D construct LP perpendicular to MN.
(4) With L as center and radius OD, strike arc cutting PL at E.
(5) Join points E and F with a straight line.
(6) With D as center and $2OD$ as radius, strike arc cutting PL at G.
(7) With O as center and OG as radius, strike arc cutting sides of angle at J and K.
(8) With J as center and radius EF, strike arc cutting arc JGK at H.
(9) With K as center and radius EF, strike arc cutting arc JGK at I.
(10) Draw OH and OI, which trisect angle AOB.

An analysis of this proposed solution produces

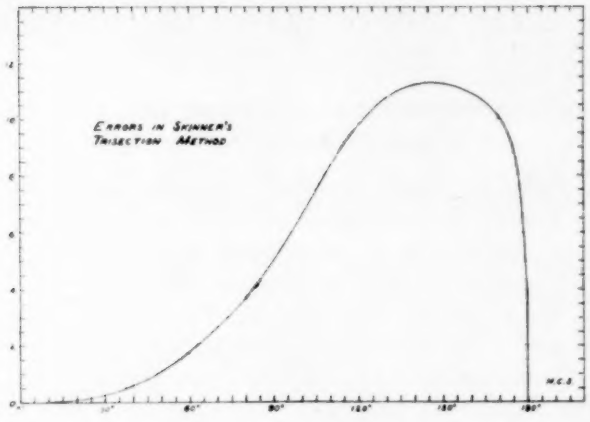
$$\sin\frac{\gamma}{6}=\frac{1}{2}\sqrt{\frac{5-2\cos\frac{\alpha}{2}-3\cos^2\frac{\alpha}{2}}{5+4\cos\frac{\alpha}{2}}}$$

where $\gamma/3$ = angle IOK = angle JOH, each of which are purported to be $\frac{1}{3}$ of the given angle AOB, which is called α in the formula.

Using this relationship, $\gamma/3$ was determined for various values of α, from which the errors given below were obtained.

α in Degrees	Error of $\gamma/3$ in Minutes
0	0°00′00″
30	0°00′14″
60	0°01′42″
90	0°05′06″
120	0°09′46″
150	0°11′18″
180	0°00′00″

A few more critical points were determined for plotting the curve.



GENERAL ANALYSIS OF SKINNER'S TRISECTION METHOD

Let $OD = 1$.

$DL = OD \cos \alpha/2 = \cos \alpha/2$.

$DG = 2OD = 2$.

$LG = DL + DG = \cos \alpha/2 + 2$.

$LO = OD \sin \alpha/2 = \sin \alpha/2$.

$OG = \sqrt{\overline{LG}^2 + \overline{LO}^2} = \sqrt{(\cos \alpha/2 + 2)^2 + (\sin \alpha/2)^2}$

$EL = OD = 1$.

$ED = EL - DL = 1 - \cos \alpha/2$.

$DF = 2LO = 2 \sin \alpha/2$.

$EF = \sqrt{\overline{ED}^2 + \overline{DF}^2} = \sqrt{(1 - \cos \alpha/2)^2 + (2 \sin \alpha/2)^2}$

$$\sin \gamma/6 = \tfrac{1}{2} IK/OK = \tfrac{1}{2} EF/OG$$

$$= \frac{\tfrac{1}{2}\sqrt{(1 - \cos \alpha/2)^2 + (2 \sin \alpha/2)^2}}{\sqrt{(2 + \cos \alpha/2)^2 + (\sin \alpha/2)^2}}$$

$$= \frac{1}{2} \sqrt{\frac{1 - 2 \cos \alpha/2 + \cos^2 \alpha/2 + 4 \sin^2 \alpha/2}{\cos^2 \alpha/2 + 4 \cos \alpha/2 + 4 + \sin^2 \alpha/2}}$$

$$= \frac{1}{2} \sqrt{\frac{3 \sin^2 \alpha/2 - 2 \cos \alpha/2 + 2}{5 + 4 \cos \alpha/2}}$$

$$= \frac{1}{2} \sqrt{\frac{5 - 2 \cos \alpha/2 - 3 \cos^2 \alpha/2}{5 + 4 \cos \alpha/2}}$$

$$\gamma/3 = 2 \arcsin \frac{1}{2} \sqrt{\frac{5 - 2 \cos \alpha/2 - 3 \cos^2 \alpha/2}{5 + 4 \cos \alpha/2}}$$

THE SELECTION OF BOOKS IN THE FIELD OF MATHEMATICS

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Today there is greater demand for books on mathematics than ever before. The reason is not hard to find. Most of our present-day civilization is built upon mathematical applications. The man who designs the airplane, the soldier who adjusts his sights, the housewife who plans her budget, and the philosopher who arrives at the truth by deduction, are all using the method of mathematics. To choose from the product of the presses the books that will meet most effectively this need, we must understand the nature and scope of mathematics and must establish criteria for selecting individual books.

What is mathematics—this cornerstone of modern society? The old notion that it was "figures" or "the science of quantity" has given way to a much broader definition. The most advanced developments in the field have brought the realization that quantity is only one aspect of mathematics. The essence of the subject, it is now seen, lies in classes and in relations, or, in "the study of types of order," as the philosopher Nagel[1] puts it. Mathematical thinking is not concerned exclusively with magnitudes nor numbers nor geometric entities nor special configurations. It is applicable to many, perhaps all, kinds of subject-matter. It is dependent upon implication—the deduction of one proposition from another. Mathematical symbols are not necessary to mathematical thinking, but they are a modern tool which makes for economy of thought. Mathematics is a method. In the summarizing words of Professor Whitehead, it is the study "concerned with the logical deduction of consequences from the general premises of all reasoning."[2]

Naturally a method with such broad utility will interest many groups of readers. More specifically, the demand for mathematical books may be divided into three main categories:

1. General textbooks of elementary mathematics. This includes all the mathematics normally taught below the third year of college: arithmetic, algebra, plane geometry, trigonometry, solid geometry, analytical geometry, differential and integral calculus.

[1] E. Nagel, in *Erkenntnis*, 2 (1931), 313.
[2] Alfred North Whitehead, in *Encyclopaedia Britannica*, 14th ed., 15, 85.

2. Books stressing application of mathematics to particular vocations or trades. For example, there are special works for carpenters, soldiers, and electricians. As a rule, however, the books needed by engineers, physicists, and chemists lie in categories 1 and 3.

3. Treatises on higher mathematics, written for advanced students. This class includes all books of mathematics above basic integral calculus.

Although some original work not previously published, is found in books of class 3, the first product of mathematical research usually appears in scholarly journals. The principles evolved in these periodicals gradually sift down to the level of the books discussed above. As selectors of books, we are not concerned with the evaluation of journals. There is only one important criterion of such work: does it answer previously-unanswered questions?

Since, ultimately, differential book selection means choosing between two books, our job is to determine which of the two under comparison possesses the greater number of desirable attributes and the higher degree of excellence in each attribute. But which is more important in a book, the possession of a few desirable qualities in high degree or of many in lower degree? This calls for an evaluation of the relative importance of the different criteria. In the following discussion attempt has been made to list the qualities in groups, according to their significance. One could go still farther, if one wished, and give to each criterion a numerical value, or rank the criteria within each group, but it is doubtful whether such an elaborate system would ever be used by practical selectors. Choices must usually be made so quickly that complicated methods cannot be employed. A knowledge of desirable features and a conscientious effort to determine by direct observation or through reviews the extent to which the potential purchases meet the standards, seem to be the highest attainable bases of selection.

There are two kinds of criteria: primary and secondary. Primary criteria are those directly applied to the actual, particular, individual book being considered. Secondary criteria are those which, while not forming certain or final basis for judgment, provide clues to the probable value of the book. Secondary criteria, identical for many books, may be enumerated thus:

1. The author's qualifications to write the book, as indicated by professional or vocational eminence, reputation of earlier writings, special training or experience for the work at hand.

2. The publisher's reputation in general and in the special field of the book being judged. Appraisal of the other contributors to the publisher's list helps in evaluating the firm.

3. The number of earlier editions of the book, as a measure of success and of opportunity for correction of errors.

4. The author's aim.

5. The date of copyright, as indicative of recency of the subject-matter.

These are the general standards helpful in rough evaluation of non-fiction. Books for which incomplete data are available must often be selected or rejected on the basis of these five points.

For judicious selection we need to be aware of the primary criteria of mathematical works. What are the characteristics that distinguish a good book of *elementary mathematics* from an inferior book of this type?

Of first importance are:

1. Suitability for a given grade or for a group having given mathematical background. This is not difficult to determine, because the prerequisites for the study of each special branch of mathematics are so iron-clad. The level of the book can be found from the title or the preface.

2. Teaching of one process at a time.

3. Illustrative solutions which show how the abstract principles are applied.

4. Uniform, meaningful diagrams on the same pages as the sections to which they pertain.

5. Problems for diagnostic, practice, and review purposes.

6. Basic principles not obscured by a maze of detail or computation.

7. Clarity of statement; expecially, the avoidance of ambiguity.

8. Careful definition of new terms.

9. Fullness of treatment of various topics in proportion to importance as well as difficulty.

10. Coverage of the topics prerequisite to more advanced work in mathematics. In considering the products of reputable authors and publishers the actual determination of this point rarely arises. However, if it does, comparison of the contents of an individual book with the topical requirements of the state board of education or the College Entrance Examination Board or the state university will quickly reveal adequacy or inadequacy.

11. Necessary foundation for subsequent study of chemistry, physics, engineering, and other fields requiring knowledge of mathematics. Satisfaction of point 10 assures such a foundation. A thorough knowledge of fundamentals, rather than an acquaintance with obscure topics, is desired. The following are the most used operations in the fields mentioned: substitution in formulas, solution of simple equations, handling of ratio and proportion, making and reading of graphs; the four fundamental operations of addition, subtraction, division, and multiplication of integers, fractions, and decimals; conversion of fractions into decimals, use of exponents; simple application of sine, cosine, and tangent.

Of second importance are:

1. Text broken into convenient sections for assignment and testing purposes.
2. Clear type for maximum legibility, minimum eye-strain.
3. Practice exercises not classified so carefully by type that solution is automatic for the student.
4. Use of interest-promoters: applications within the experience of the reader; historical or biographical material.

Of third importance are:

1. Substantial binding.
2. Arrangement of problems according to difficulty, so that the teacher can make assignments for three levels of student ability.
3. Table of contents to aid the teacher in planning the course.
4. Repetition of problems in two or more sections of the book, when such repetition shows the reader the possibility of more than one solution or when it proves the greater ease of solution by the latest method studied. This makes the utility of the advanced work evident to the student.
5. Provision of the answers to the problems. For books below algebra, the answers should be bound separately for teacher use only. For algebra and above, in addition to separate answers for the teacher, some answers should be given in the book for student use. The answers given should be those to problems involving very long computations. To de-emphasize routine operations and to stress method are the aims.

At the present time the most pressing need is for books showing *the application of mathematics to special vocations and trades.* These are the books that make for well-trained technicians. Let us not decry them for being narrowly utilitarian.

In mathematics he was greater
Than Tycho Brahe, or Erra Pater;
For he, by geometric scale
Could take the size of pots of ale.
Butler. *Hudibras.* (1663)

The criteria for the evaluation of vocational books in mathematics spring directly from the special use to which these books are to be put. That the user may be able to find in one of them the method for solving some problem he encountered during the day's work is the real test of value.

Of first importance are:

1. Suitability for a group with limited mathematical background. Most readers have a working knowledge of arithmetic and a rusty knowledge of algebra and geometry.
2. Self-teachability—the requirement of minimum help from other sources. Clarity is more important than brevity.
3. Demonstrated application to definite situations. Principles the utility of which is not directly shown in the book, are almost worthless to the practical man.
4. Uniform, meaningful diagrams that appear on the same pages as the sections to which they pertain.
5. Practice in estimating a result before computing.
6. Inclusion of only the most important mathematical tools. The intent is to give the reader a working knowledge of the methods applicable to his daily problems. The minimum needs for most trades and vocations are the following: speed and accuracy in addition, subtraction, multiplication, and division; use of decimals, fractions, and ratio; the calculation of area and volume; the handling of angles and triangles. In addition, special groups have other needs.

Of second importance are:

1. Great emphasis on accuracy of computation, neatness, and ability to copy numbers correctly.
2. Careful labelling of each process by name, enabling the reader to recognize the process when he encounters reference to it in other technical books.
3. Clear print.
4. Index as well as table of contents. This increases the reference value of the book.
5. Problems for practice.

Of third importance are:

1. Substantial binding.
2. Provision of answers to some of the practice problems. This gives the user a check on his solutions.

We turn now to *books of higher mathematics, written for the advanced student.* Here we are dealing, not primarily with immediately useful routines, but with difficult ideas, usually clothed in elaborate symbolism. To judge these books well, the evaluator should have expert knowledge of the subject. Without this knowledge he must rely upon the secondary criteria already enumerated or upon the opinions of other judges. The standards which follow reveal the difficulty of selecting books in the third category.

Of first importance are:

1. New ideas which fill gaps in previous knowledge; or a gathering-together of ideas formerly scattered.
2. Inclusion of the latest advances in the field.
3. Clear, consistent symbolism throughout the book.
4. Definition of new terms or terms used in new senses.
5. Employment of simplest methods consistent with sound mathematics.
6. Adequate demonstration or documentation of difficult points, but minimum proof of the obvious. In the words of one learned reviewer, a specialist, "Many passages in this book seem to cry aloud, 'Give us references, or give us proofs!' But they cry in vain." There can be no absolute application of this standard; equally-qualified readers will disagree on what is "adequate."
7. Full treatment of a few topics, rather than fragmentary discussion of many.
8. Clarity of expression.

Of second importance are:

1. Minimum number of different symbols.
2. Minimum errata and errata in errata.
3. Detailed index.
4. Uniform, meaningful figures on the same pages as the sections to which they pertain.

Of third importance are:

1. Title descriptive of the scope of the book.

2. Detailed list of all symbols used in the book, if many unusual ones employed.

3. Bibliography, especially in books devoted to rapidly developing subjects in which formal instruction is recent or not widespread.

We concede that under the present conditions of book-buying the individual selector cannot readily check each proposed mathematical purchase with all the criteria outlined for a category. Moreover, we realize that few books meet all the standards applicable. Yet, it is undeniably true that a knowledge of the past products of authors and publishers, tempered by basic bibliographical information, the claims of advertisers, and the observations of reviewers, considered in the light of what constitutes excellence, must result in sounder evaluation than we could expect, were one or more of these factors ignored.

Supplementary Data

Important *publishers* of mathematics books:

Allyn and Bacon; American Book Co.; Appleton-Century; Cambridge University Press; Chapman and Hall; University of Chicago Press; Ginn; Heath; Hodder and Stoughton; Holt; Houghton-Mifflin; Lippincott; Longmans; Macmillan; McGraw-Hill; Oxford University Press; Prentice-Hall; Princeton University Press; Ronald; Scott, Foresman; Scribner; Silver, Burdett; Van Nostrand; Williams and Wilkins; World Book Co.; and a number of German firms whose books are not now available.

Important *aids* in the selection of books in this field:

School Science and Mathematics, *American Mathematical Monthly*, *Mathematical Gazette*, *Mathematics Teacher*, *National Mathematics Magazine*, *New Technical Books* (New York Public Library), *Science*, *Scripta Mathematica*, *Technical Book Review Index*, *University of the State of New York* (Regents) *syllabi in mathematics*, and similar syllabi for other school systems.

In addition to reviews in several of the journals mentioned above, the following were useful as sources of information and as stimuli to thought in writing this paper:

Bureau of Education. *The Problem of Mathematics in Secondary Education*. Bulletin No. 1. Government Printing Office. 1920.

Fuller, Florence D. *Scientific Evaluation of Textbooks*. Houghton. c1921.

Leonard, Clarence J. *Mathematics in the Training of Industrial Workers*. In *Mathematics Teacher*, March 1941, 124.

Keyser, Cassius J. *The Pastures of Wonder*. Columbia. 1929.

Maxwell, Charles R. *The Selection of Textbooks*. Houghton. c1928.

Needham, Joseph. *Order and Life*. Yale. 1936.

NICKLE, GEORGE H. *The Mathematics Most Used in the Sciences of Physics, Chemistry, Engineering, and Higher Mathematics.* In *Mathematics Teacher,* February 1942, 77.

ROTHE, C. A. *Mathematics as Applied to Apprenticeship in Trades.* In *Mathematics Teacher,* January 1942, 29.

SMITH, DAVID E. *The Teaching of Geometry.* Ginn. 1911.

U. S. Office of Education. *Instruction in Mathematics.* Bulletin No. 17. 1933.

WHITEHEAD, ALFRED N. *Mathematics, Nature of.* In *Encyclopaedia Britannica,* 14th edition, 15, 85.

SCIENCE AND THE VICTORY CORPS PROGRAM IN BOULDER HIGH SCHOOL

G. D. MCGRATH

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There undoubtedly has never been a time during the history of science education on the secondary level when more attention has been focused on making changes and adaptations to meet newly created needs. For some schools, transitions will be slow while others will launch out rapidly into a new science curriculum.

Release of plans for the Victory Corps Program has probably caused nearly every school system to re-examine its contribution through its science department. Stress is being placed largely on pre-induction science courses with pre-flight aeronautics apparently taking the lead. On the surface, it would seem that it will not suffice to just intensify present offerings, but some significant changes will have to be made.

At the outset, many problems appeared on the horizon for any new programs. There was some doubt as to just what science information and skills leaders in our armed forces were desirous of having mastered by potential inductess. Vocabulary burdens and lack of organized content added to the complexity. The grade placement and degree of technical nature offered difficulties. Shortage of qualified teachers, lack of texts, and methods of pupil recruitment or guidance into special activities increased the confusion.

And yet, in spite of these obstacles, something had to be done and it had to be quickly and expediently attacked with courage and resourcefulness. Pupils were desirous of having a new program which would be more closely knitted into the war effort, and friends of education were looking anxiously to see what the answer of schools would make.

Thus, with the realization of the problems and necessity of action confronting them, a special faculty committee of Boulder High School set out in September to plan for the "new order." A careful survey of objectives and plan of the Victory Corps served as an introductory activity. Conferences with officers of the armed forces gave a more vivid picture of just what skills and pre-induction training were most desirable. Professional background of the staff was studied to ascertain qualifications for new-type subjects. As a special effort, all of the pamphlets, books, and materials relating to the science of the war effort were obtained. Then a study of courses to meet the wartime needs was begun. A plan was worked out to include new courses with a minimum of confusion, so that a return to the former program could easily be made after the war—if it is ever desirable to do that.

A comparison of the old and the newly adopted programs will summarize the results.

The Old Program	The New Program
1. Seven classes of biology	1. Seven classes of biology, with special emphasis on physiology, anatomy, and hygiene of the human system.
2. Four classes of general chemistry	2. Three classes of general chemistry; one class of industrial-type chemistry to lessen break-in training for those planning to work in chemical industries.
3. Three classes of general physics	3. One class in general physics; one class for boys with special emphasis on war applications; one class for girls with special emphasis on problems in the home involving physics.
4. Two classes of pre-flight aeronautics	4. Two or more classes of pre-flight aeronautics, depending on demand.
5. One class in geology	5. Geology to be dropped for the present.
6. One class in mental hygiene	6. Mental hygiene to be dropped for the present, but significant areas to be incorporated into other courses.
7. One class in general photography	7. Three classes in war photography.
	8. One class in war science
	9. One class in advanced radio and electricity for high school students.

The program is not suggested as meeting every need, but it represents the best answer that could be submitted by the committee. Information on what other schools are doing is always sought and keenly appreciated by the committee. Shifts in teaching loads and elimination of much overlapping of content of courses eased some apparent discrepancies.

Several additional changes are contemplated and may soon be worked out. These include bringing consumer education back into the science department and intensifying its approach, adding a course in elementary clinical work or medical technology for assistants or aides in the medical corps, a course in meteorology, and cooperation with the vocational department in auto mechanics. There may also be some cooperation with the mathematics department in separate courses in navigation. The home making department is turning to special courses in nutrition, first aid, home nursing, and child care, so these have been left out of the regular science curriculum. Several other departments in the school are making interesting changes and a whole new atmosphere seems to be in the offing.

A word concerning proposed content of two of the new courses might clarify our goals.

Staff members have been hard at work for a long time collecting materials and organizing the courses. Much of the material has been developed after consultation with men in the armed forces.

War Science is planned to give an intensive treatment of as much scientific information and skills as can possibly be presented. It will be as technical as an inductee should need and will pull together and intensify materials from many areas of science. Practical information will be stressed.

The content of War Photography will be based on the Basic Photography Course given at some of the photography training schools for the army. Much new special equipment has been secured for this course.

It may well be admitted that many problems may still present themselves. There may be danger in going too far or going too rapidly, but, on the other hand, it may prove to be a shot in the arm to arouse us from any lethargy which may have been developing, and point the way to an entirely new concept of just what in science is most worthwhile. We may find that the secondary school science needs of youth during war time are really not very much different than the actual science knowledge needed during peace time.

SCIENCE ACTIVITY STIMULATES INTEREST

JOHN J. COCHRANE
Roosevelt Junior High School, Rockford, Illinois

Surveying the science strides of the day excites the interest of both the science teacher and student. In teaching science in the junior high school there is a splendid opportunity to present the science of today through an activity unit. Such a plan has been especially stimulating in the writer's classes.

Each student in the class was appointed science editor of his own newspaper. He planned the make-up, placement of stories, headlines, cartoons, and all other details of his own paper. Each newspaper was to be a review of science progress made in recent months.

References for the unit were, of course, all available sources of science news. Current monthly journals, weekly reports, newspapers, radio talks, movie news, and industrial communications were gathered in the classroom for careful study. Students read and re-read this material, selecting important points, and rewriting in concise form for their papers.

There was much chance for originality. Several students were clever with their science cartoons, editorials, and headlines. The teacher spent most of the class period going from student to student offering suggestions and complimenting work well done.

Intense interest was especially evident and never lagged during the several days of the activity. Once the students understood how to proceed, they became absorbed in what they were doing. Even the less capable made noble efforts.

When the papers were completed, the best were placed on the bulletin board. Students from one class were often seen viewing the papers of another. There was no test. The papers testified to the results. In reading, thinking over, and summarizing the science news, much was learned. The students decided that science has, and is, changing the world considerably; that to live happily and usefully today, one must have some knowledge of science; and that this knowledge and understanding will be even more necessary in the future.

There was much tangible evidence that most of the students were not only very interested, but were conscious of a new regard for science at the conclusion of the unit.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1801, 3, 4, 6. *J. Frank Arena, Hardin, Ill.*

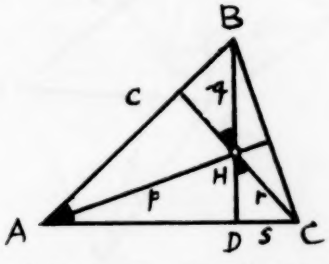
1801, 2. *Morris J. Chernofsky, Brooklyn, N. Y.*

1806. *S. E. Field, Ironwood, Mich.*

1807. *No solution has been offered.*

1808. *Proposed by Marmis Charosh, Brooklyn, N. Y.*

In triangle ABC, attitudes AF, BD, CE meet at H. If $AH=p$, $BH=q$, $CH=r$, prove: $aqr+brq+cpq=abc$.



First solution by Hugo Brandt, Chicago, Ill.

The marked angles are all equal to angle A; if $BD=h$ and $DC=s$, then in similar triangles ABD and HCD, $h/c=s/r$. Hence $c/r=h/s=\tan C$, and similarly $a/p=\tan A$, $b/q=\tan B$. Since in any triangle $\tan A+\tan B+\tan C=\tan A \tan B \tan C$, we have $a/p+b/q+c/r=abc/pqr$.

$$\therefore \quad aqr+bpr+cpq=abc.$$

Second solution by W. Kirk, West Chester, Pa.

Using the figure, angle $BHC=180°-A$, $CHA=180°-B$, $AHB=180°-C$. Also using the formula for area of a triangle in terms of an angle and the included sides, one obtains:

$$\triangle ABC=\triangle BHC+\triangle AHC+\triangle ABH$$

$$\frac{bc\sin A}{2}=\frac{qr\sin A}{2}+\frac{pr\sin B}{2}+\frac{pq\sin C}{2}.$$

Since

$$\frac{\sin A}{a}=\frac{\sin B}{b}=\frac{\sin C}{c},$$

$$abc\frac{\sin A}{2a}=aqr\frac{\sin A}{2a}+brp\frac{\sin A}{2a}+cpq\frac{\sin A}{2a}.$$

Hence

$$abc=aqr+brp+cpq.$$

A solution was offered also by the proposer.

1809. *Proposed by Walter H. Carnahan, Indianapolis, Ind.*

Triangle ABC is scalene with equilateral triangles ABD, ACE and BCF constructed so that they do not overlap.

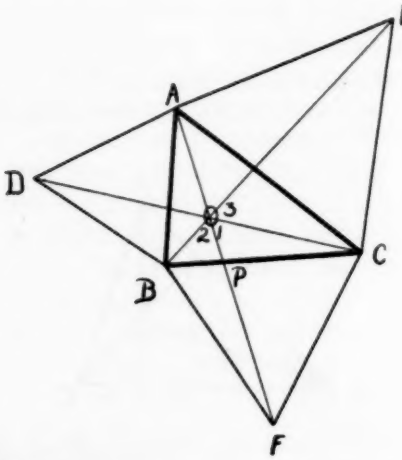
Show that 1. $AF=BE=CD$.

2. AF, BE and CD are concurrent.

3. AF, BE and CD form 60° angles at point of concurrence.

Solution by Thomas A. Pickett, South Weymouth, Mass.

Construct equilateral triangles on the sides of scalene triangle as directed.



Draw AF and DC.

Hence $AF=DC$, and $\angle AFB=\angle DCB$.

Triangles ABF and DBC are congruent. (s.a.s.)

Now OCP and BPF are similar triangles, hence $\angle 1=CBF=\angle 60°$.

Since these angles are equal and opposite the side CF of the equilateral triangle BCF, O is on the circle circumscribing triangle BCF.

Draw OB. Then $\angle 2 = 60°$. (Measured by $\frac{1}{2}$ arc BF.)

Now $\angle AOC = 120°$ (Supplement of $\angle 1$). Since this angle is opopsite the side AC of the equilateral triangle ACE (and not overlapping), the point O is on the circle circumscribing triangle ACE.

Draw OE. Then $\angle 3 = 60°$. (Measured by $\frac{1}{2}$ arc EC.)

Hence BOE is a straight angle, and BE is a straight line through O.

AF, BE and CD are concurrent, and the vertical angles about O are all angles of 60°.

Triangles ABE and ADC are congruent. (s.a.s.)

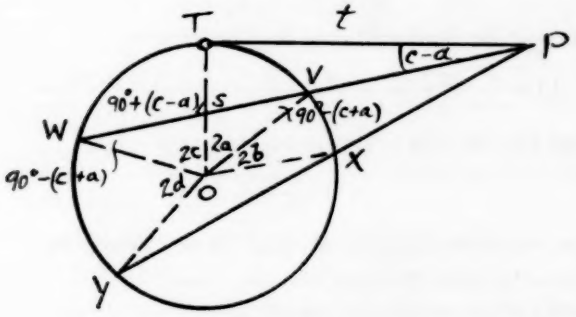
$BE = DC$ (corres. sides). But $AF = DC$, hence $AF = BE = CD$.

Solutions were offered by Hugo Brandt, Chicago, Ill. and W. R. Smith, Suttons Bay, Mich.

1810. *Proposed by Aaron Buchman, Buffalo, N. Y.*

If from an outside point P, tangent PT and secants PVW and PXY are drawn to circle O, PVW between PT and PXY, and if $\overset{\frown}{TV} = 2a$, $\overset{\frown}{VX} = 2b$, $\overset{\frown}{TW} = 2c$, $\overset{\frown}{WY} = 2d$, prove that

$$\frac{\cot a + \cot b}{\cot c + \cot d} = \frac{\csc^2 a}{\csc^2 c}.$$



Solution by Proposer

Let $PT = t$, and let the radius of the circle O be r.

It is easily shown that chord $WT = 2r \sin c$.

In triangle TWP, $WT : TP = \sin P : \sin W$.

Thus, $2r \sin c : t = \sin (c - a) : \sin a$.

Or, $2r : t = \sin (c - a) : \sin c \sin a$

And

$$\frac{2r}{t} = \cot a - \cot c. \tag{1}$$

Similarly, by using triangle TYP,

$$\frac{2r}{t} = \cot (a + b) - \cot (c + d). \tag{2}$$

From (1) and (2),

$$\cot a - \cot c = \cot (a + b) - \cot (c + d). \tag{3}$$

Expand the cotangent of the sum of two angles, clear of fractions, factor, and replace $(1+\cot^2)$ by $\csc^2$, and

$$\csc^2 c(\cot a+\cot b)=\csc^2 a(\cot c+\cot d)$$

from which the required relation results.

Solutions were also offered by Hugo Brandt, Chicago and M. Kirk, West Chester, Pa.

1811. *Proposed by Celia Milleo, Interlaken, N. Y.*

Show that the area of the triangle formed by joining the centers of the escribed circle is $abc/2r$, where a, b, c, and c are sides of the original triangle and r is radius of inscribed circle.

Solution by Hugo Brandt, Chicago, Ill.

If the radii of the escribed circles are r_a, r_b, r_c, and $2s=a+b+c$, the perimeter of the triangle, the area of the triangle with corners in the centers of these circles is seen to contain the original triangle and three others with bases a, b, c respectively and altitudes r_a, r_b, r_c respectively.

Or $A=\frac{1}{2}(ar_a+br_b+cr_c)+rs$ where

$$r_a=\frac{rs}{s-a}, \quad \text{etc.}$$

$$\therefore \quad A=\frac{r^2s}{2r}\left(\frac{a}{s-a}+\frac{b}{s-b}+\frac{c}{s-c}+2\right)$$

Considering that the bracketed term may be written

$$\frac{a}{s-a}+1+\frac{b}{s-b}+1+\frac{c}{s-c}=\frac{s}{s-a}+\frac{s}{s-b}+\frac{c}{s-c}=\frac{abc}{(s-a)(s-b)(s-c)}$$

and also that $r^2s=(s-a)(s-b)(s-c)$ we finally get

$$A=\frac{abc}{2r}.$$

A solution was offered also by M. Kirk, West Chester, Pa.

1812. *Proposed by Helen Morissey, Hartford, Conn.*

If A, B and C are the angles of a triangle prove that $1-8\cos A\cos B\cos C$ is always greater than zero.

Solution by Hugo Brandt, Chicago, Ill.

To prove $1-8\cos A\cos B\cos C\geqq 0$, is equivalent to showing that $f=\cos A\cos B\cos C$ has a maximum of $1/8$.

Now $\cos C=\cos[180^\circ-(A+B)]=-\cos(A+B)=\sin A\sin B-\cos A\cos B$ and $f=\cos A(\sin A\sin B\cos B-\cos A\cos^2 B)$. For a given A (=constant) to find a maximum, put $df/dB=0$.

$df/dB=\cos A(\sin A\cos 2B+\cos A\sin 2B)=\cos A\sin(A+2B)=0$. Since $\cos A\neq 0$ $\sin(A+2B)=0$ and since $A+2B\neq 0$, $A+2B=180^\circ$ $B=90-A/2$, $C=180-A-(90-A/2)=90-A/2$.

Substituting the values of B and C in f, $f=\cos A\sin^2 A/2=(1-2\sin^2 A/2)\sin^2 A/2$.

Now put $s=\sin A/2$, then $f=s^2-2s^4$. Then $df/ds=2s\ (1-4s^2)=0$, for maximum and minimum values.

When $s=0$, a minimum value is obtained. When $s=\frac{1}{2}=\sin A/2$, or when $A=60^\circ$ and $B=60^\circ$ a maximum value is found.

By substitution, $f=(\cos 60)^3=1/8$.

A solution was offered also by M. Kirk, West Chester, Pa.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below:

1801, 4. Eugene Tilus, Jr., Chicago, Ill.

1802. Audrey Eileen Reid, Acadmy of St. Elizabeth, Convent Station, N. J.

1806. Edgar Cook and K. A. G. Miller, Toronto, Canada.

SOLUTION OF PROBLEMS

1825. *Proposed by Myrtie Hyatt, Newburg, N. Y.*

If $a:b=b:c$, show that

$$\frac{a^2-b^2+c^2}{a^{-2}-b^{-2}+c^{-2}}=b^4.$$

1826. *Proposed by Martyn Summerbell, Lewiston, Maine.*

If

$$\frac{a+b}{1-ab}+\frac{c+d}{1-cd}=0,$$

prove that $(a+b+c+d)=abcd(1/a+1/b+1/c+1/d)$

1827. *Proposed by Hugo Brandt, Chicago, Ill.*

Given a line $x=-t$ and a point $A(t, 0)$, to find the locus of all points including $(0, 0)$ for which the squares of the distances from A are proportional to their distances from the line.

1828. *Proposed by Benjamin Carpenter, Lake Forest, Ill.*

For triangle ABC, prove:

$$\frac{2\sin A\sin B\sin C}{(\sin A+\sin B+\sin C)}=\tan A/2\tan B/2\tan C/2.$$

1829. *Proposed by Fred Jones, Scott's Corners, N. Y.*

On the side BC, of triangle ABC, as hypotenuse an isosceles right triangle is constructed with P as third vertex and on the same side of BC as A. Prove: $2PA^2=b^2+c^2-2bc\sin A$.

1830. *Proposed by Walter R. Warne, Rochester, N. Y.*

Find the terms of p, q, r, the value

$$\frac{\alpha^2+\beta^2}{\alpha\beta},$$

where α, β, γ are the roots of $x^3+px^2+qx+r=0$.

Give me the youths who have been truly awakened spiritually and I'll take my chances with them, whatever their I.Q. ratings may be.—*Roger W. Babson.*

SCIENCE QUESTIONS

May, 1943

Conducted by Franklin T. Jones
10109 Wilbur Avenue, S. E., Cleveland, Ohio

Contributions are desired from teachers, pupils, classes and general readers. Send examination papers from any source whatsoever.

It is natural that questions connected with the War Effort will be especially appreciated.

Questions on any part of the field of science; questions having to do with the pedagogy of science; new applications of old ideas; present variations of perhaps ancient questions; anything that appeals to the reader, or might appeal to other readers—all are wanted.

What interests you, will most likely, interest others also.

We will endeavor to obtain answers to all reasonable questions. It is always valuable to get questions whether we can get the answers or not.

Contributors to SCIENCE QUESTIONS are accepted into the GQRA (Guild of Question Raisers and Answerers).

Classes and teachers are invited to join with others in this cooperative venture in science.

JOIN THE GQRA!

Scrapbook Pictures of GQRA Members

It has been suggested to the Editor that a book of pictures of members of the GQRA should be prepared. It is true that many of the contributors to SCIENCE QUESTIONS are and have been leaders in Science and Mathematics affairs, and that such a collection of pictures would provide important information concerning educational leaders during the period since 1910.

Please send in your picture—snapshot or otherwise.

SCIENCE AND INDUSTRY

Read the following to Keep Up in 1943

43. *Synthetic Rubber*—Charles C. Price, University of Illinois, Urbana, Ill. Presented at the Chemistry Section of the Central Assn. of Science and Mathematics Teachers, Chicago, November, 1942. Printed in SCHOOL SCIENCE AND MATHEMATICS, p. 251, March, 1943.

44. *Isaac Newton*—E. W. Melson, The Bausch & Lomb Optical Co., *The Educational Focus*, Spring 1942.

    Biographical Sketch, Experiments, Illustrations, Corpuscular Theory of Light. (Be sure to read in connection with 45. *The Electron Microscope.*)

45. *The Electron Microscope*—E. F. Burton, University of Toronto, *The American Scholar*, Autumn, 1942, pp. 403–415; Chart—Natural Phenomena, p. 404; Limits of the Visual Microscope; The Ultramicroscope to "Push Down the Visibility of Particles"; Electrons in Motion have a Wave Property; Electron Lenses; Diagrams; Compound Electron Microscope; Magnetic Lenses; Diagrams, p. 414; Future Possibilities.

46. *RCA Electron Microscope*—RCA Division of Radio Corporation of America, Camden, New Jersey, *Address* M. C. Banca, Engineering Products Division.

    "Thank you for your recent inquiry requesting further informa-

tion on the RCA Electron Microscope and we are sending you literature describing the instrument and its accomplishments.

"I think it would be quite satisfactory to call to the attention of teachers the literature that is available on the Electron Microscope." (Free on request.)

By all means ask for the two pamphlets which will be sent to you. "Opening New Frontiers of Knowledge" and "Into Unseen Worlds."

47. *How to Teach Fire-Fighting*—Walter Kidde & Company, Inc., 346 West St., Bloomfield, N. J.

"It tells how to handle demonstrations effectively, how to set up fire tests, how to explain extinguisher action. Write now. We'll mail you a copy." Address 346 West St., Bloomfield, N. J.

BAROMETER TO ALTIMETER

991. *Proposed by K. F. Keirstead, M.A., Principal, Saint Andrews Public Schools, Saint Andrews, New Brunswick, Canada (GQRA No. 270).*

A barometer reads from 400 millibars to 1,013 millibars (360 degrees). It is desired to convert this instrument into an altimeter by recalibrating to read in feet, by intervals of 5,000 feet.

From the data below draw a graph—

Pressure in millibars	*Altitude in feet*
400	24,370
500	18,520
600	13,740
700	9,700
800	6,200
900	3,112
1,000	348
1,013	Sea Level

Given that the face of the instrument is 4 inches, from the graph obtain the data for the calibration of the dial.

(In submitting answer please send your drawing, preferably in black ink, so that a cut may be made for publication. On a separate sheet from answer, please. Thanks!)

Additional Information on How to Draw Chart by Hollis D. Hatch, English High School, Boston, Mass. (GQRA, No. 264).

Mr. Keirstead (GQRA 270) in question 991 gives a table of altitudes corresponding to barometer readings 100 millibars apart and asks how to find the pressure readings for intervals of every 5,000 ft.

In the first place you can NOT make your table by ordinary or linear interpolation because the altitude varies as the logarithm of the ratio of the pressure at the ground to the pressure at a given height. This is not the whole story as temperature, latitude, humidity, and the local value of "g" affect the barometer reading at a given height. Of these temperature is by far the most important. For a more complete discussion see Smithsonian Meteorological Tables 1931 page XIV.

In SCHOOL SCIENCE AND MATHEMATICS (Vol. 36, p. 409, April 1936) I showed that the relation of altitude, barometric pressure and temperature was nicely expressed by: $S = 123(F + 459) \operatorname{Log}_{10}(B_0/B)$ where

S = the altitude in feet
F = average Fahrenheit reading
B_0 = ground barometer reading
B = aerial barometer reading

The above shows that for accurate results no fixed pressure can be marked 5,000; 10,000; 15,000 ft., etc., as Mr. Keirstead hoped because that assumes constant temperature at all levels and every day. The table given agrees with my formula if the average temperature up to 400 ft. is about 45°F., up to 10,000 ft. 32° and up to 25,000 ft. 30°F. At some particular place and season an average temperature may be used and I am pretty sure the formula will be more accurate than an ordinary aneroid barometer.

If you still wish to calibrate your barometer assume an average temperature for a given height and solve the formula for B. Example: If $S=5{,}000$ and $F=40°$

$$5{,}000=123(40+459)(\log 1{,}013-\log B)$$
$$5{,}000=61{,}380(3.00561-\log B)$$
$$\log B=2.92415 \text{ and } B=840 \text{ millibars.}$$

WORK FOR NON-BOOK-MINDED PUPILS

994. *Proposed by Miss Lillian A. MacDonald (GQRA, No. 327), South Side High School, Newark, N. J.*

"At present my chief problen is to find suitable work for non-book-minded pupils who are scheduled for a non-mathematical physics course.

"We have used simplified laboratory work and motion pictures with very satisfactory results.

"Is this problem peculiar to the East?

"I should be glad to know what other schools are doing along this line."

Answer by Norman R. D. Jones (Elected to the GQRA, No. 434), South West High School, St. Louis, Mo.

The reader is referred to an article in the February, 1943, copy of SCHOOL SCIENCE AND MATHEMATICS—*"A Modern Method of Teaching Science"—pp. 165–167.*

"Most science teachers urge their pupils to read papers and magazines and occasionally give class time to the discussion of a good article. . . .

"Many times in class . . . the writer remarked that he would like to have a course in which current science literature would be the chief source of material used. . . . Consequently when a class was received for the second semester, fully realizing that the type of student . . . would be below average and not the best for experimentation, permission was granted to try out such a procedure. . . . The two things more than anything else which probably influenced their decision to carry on the experiment was that there would be *no textbook* to carry around and *no final examination*. . . . Newspapers and science magazines were to be the so-called text. . . . Numerous clippings were found on rubber, chemical substitutes, and for St. Louis the smokeless coal problem. . . . Some of the class members were doing excellent work while others were not accomplishing much. . . . However, the opinion of the entire class was that the experiment was worthwhile, informational and appealed to their interest, and that courses of this kind should be encouraged. . . . The boy who did the least work and caused the most trouble made the surprising statement, 'I enjoyed this course best of all because one learns to think for himself and to find out about scientific inventions and discoveries'."

ACCURACY IN WEIGHING AND MEASURING

1004. *From SCIENCE NEWS LETTER, February 27, 1943, page 132.*

"Largest and smallest things are hardest to weigh. . . . The 52,000 ton

full-load displacement of the new *Iowa* class battleships may actually be as much as 52,052 tons or only 51,948 tons without anybody knowing the difference. A battleship cannot be weighed with an accuracy closer than one part in a thousand. . . . By contrast, a kilogram weight (2.2 lb.) can be compared with another with an accuracy a little less than one part in a billion. . . . A battleship is about the biggest lump of matter which human means can weigh directly. In the opposite direction the anti-pneumococcus germ or virus particle is among the smallest of living things. It would require *one octillion* of these to weigh as much as a blue whale, largest of all the animals. Far below this tiniest of germs, however, is the electron, smallest of all known objects. Its mass has been determined within an error of one per cent—but this is an accuracy of only one part in a hundred, as compared with one in a billion when kilogram weights are compared.

"As with weights so with lengths. . . . "

WAR BRINGS BENEFITS

1005. *After all the war brings us a lot of new things and among them many that are benefits. This thought came to mind as I ran through just one number of SCIENCE NEWS LETTER, March 27, 1943.*

Here are some of the benefits:

(1) A giant 130-ton electron accelerator being built in the General Electric Research Laboratory is now nearing completion. It will generate X-rays up to 100,000,000 volts. . . . Thicker metal sections can now be studied by means of X-rays (p. 200).

(2) Use of blood plasma to fight shock from fever treatments for venereal disease (p. 198).

(3) Furnace that will burn soft coal without smoke. Other features include an automatic temperature control and automatic draft compensator.

(4) A post-war "dream refrigerator" whose doors will release with a touch of the elbow—automatic defrosting, zero chamber for frozen foods, ice cubes automatically released, ice water from a faucet, storage space for your watermelon, etc.

(5) Birth rate is rising—is race suicide a thing of the past?

(6) Radioactivity is now being used to determine the amount of potassium in fertilizers and other mixtures. The method requires a relatively short time and is claimed to be accurate.

(7) Plastic, much lighter than iron, replaces strategic materials. It can be melted and run into shapes without the use of pressure somewhat the same as metal but at lower temperatures and with more exactness of mold dimensions. It has many possibilities both in war work and post-war manufacture.

WHY TEACHERS LEAVE SCHOOL

Several state studies have shown that in normal years between 30 and 40 per cent of the turnover represents shifting to better-paying teaching positions. Two factors are in the current scene. First, demands of the armed forces removed about 39,000 teachers from school positions. Second, high salaries paid in war industries and other private employment have taken about 37,000 teachers. Subtracting 11,000 as the number probably leaving for private employment in a normal year, a total of nearly 65,000 teachers have left teaching because of demands arising from the current emergency.

BOOKS AND PAMPHLETS RECEIVED

INTRODUCING INSECTS, by James G. Needham, *Emeritus Professor of Entomology*. Cloth. Pages v+129. 13×19 cm. 1943. The Jaques Cattell Press, Lancaster, Pa.

MAP INTERPRETATION WITH MILITARY APPLICATIONS, by William C. Putman, *Department of Geology, University of California at Los Angeles*. Cloth. Pages viii+67. 21×28 cm. 1943. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $1.25.

PRE-SERVICE COURSE IN AUTOMOTIVE MECHANICS, by James V. Frost, *Instructor in Automotive Trades, Brooklyn High School of Automotive Trades, Brooklyn, New York*. Cloth. Pages vi+545. 14×21 cm. 1943. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $1.96.

ELEMENTARY AVIGATION, by L. E. Moore, *Holder of C.A.A. Ground Instructor Certificate No. 53562, Teacher of Mathematics, Far Rockaway High School, New York City*. Cloth. Pages vii+222. 14.5×22.5 cm. 1943. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.50

A SECOND COURSE IN ALGEBRA, by N. J. Lennes. Revised Edition. Cloth. Pages xiii+522. 13×20 cm. 1943. Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.80.

CHEMICAL SOLUTIONS, by Frank Welcher, *Assistant Professor of Chemistry, Indiana University*. Cloth. Pages vii+404. 14.5×23 cm. 1942. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $4.75.

ELEMENTARY ELECTRICITY, by Edgar P. Slack, *Assistant Professor of Physics, Polytechnic Institute of Brooklyn*. Revised Edition. Cloth. Pages ix+305. 13.5×20.5 cm. 1943. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.00.

ANALYTICAL EXPERIMENTAL PHYSICS, by Harvey Brace Lemon, *Professor of Physics, The University of Chicago and Michael Ference, Jr., Assistant Professor of Physics, The University of Chicago*. Cloth. Pages xvi+584. 23×30 cm. 1943. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price $7.00.

SOLID GEOMETRY, by F. Eugene Seymour, *Supervisor of Mathematics, New York State Department of Education, Albany, New York* and Paul James Smith, *Head of Department of Mathematics, East High School, Rochester, New York*. Cloth. Pages vii+263. 14×21.5 cm. 1943. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.60.

PLANE AND SPHERICAL TRIGONOMETRY, by William C. Brenke, *University of Nebraska*. Cloth. Pages x+269. 13.5×20.5 cm. 1943. The Dryden Press, Inc., 103 Park Avenue, New York, N. Y. Price $1.90.

BIOLOGY FOR HIGH SCHOOLS, by Sister M. Dafrose, O.P., Ph.D., *Chairman, Science Department, Bishop McDonnell Memorial High School, Brooklyn, New York*. Cloth. Pages xvii+796. 13.5×21 cm. 1942. P. J. Kenedy and Sons, New York, N. Y.

ATOMS, STARS, AND NEBULAE, by Leo Goldberg (*Now of the McMath-Hulbert Observatory of the University of Michigan*) and Lawrence H. Aller. Cloth. Pages v+323. 14.5×21.5 cm. 1943. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $2.50.

ELEMENTS OF RADIO, by Charles I. Hellman, *Instructor in Physics, High School of Science, New York City.* Cloth. Pages xiii+318. 15×23 cm. 1943. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $2.00.

MATHEMATICS FOR THE EMERGENCY, by C. J. Lapp, *Associate Professor of Physics at the University of Iowa;* F. B. Knight, *Director of the Division of Education and Applied Psychology, Purdue University;* and H. L. Rietz, *Professor of Mathematics at the University of Iowa.* Paper. 158 pages. 20×28 cm. 1942. Scott, Foresman and Company, 623 South Wabash Avenue, Chicago, Ill. Price 80 cents.

ARITHMETIC FOR THE EMERGENCY, by G. M. Ruch, F. B. Knight, and John W. Studebaker. Paper. 176 pages. 20×28 cm. 1942. Scott, Foresman and Company, 623 South Wabash Avenue, Chicago, Ill. Price 64 cents.

INSTRUCTIONAL TESTS IN ELECTRICITY, by Benjamin C. Gruenberg with the Cooperation of Ellsworth S. Obourn. Paper. 32 pages. 16×25.5 cm. 1943. World Book Company, Yonkers-on-Hudson, N. Y. Each 16 cents or $5.00 net per package of 50.

INSTRUCTIONAL TESTS IN MACHINES, by Benjamin C. Gruenberg with the Cooperation of Ellsworth S. Obourn. Paper. 36 pages. 16×25.5 cm. 1943. World Book Company, Yonkers-on-Hudson, N. Y. Each 16 cents or $5.00 net per package of 50.

SOUND EDUCATIONAL CREDIT FOR MILITARY EXPERIENCE, A RECOMMENDED PROGRAM. Paper. Pages iii+35. 15×23 cm. 1943. American Council on Education, Washington, D. C.

THE THOUSAND MILLION, Brief stories about the United Nations. Paper. Pages vi+49. 20×26.5 cm. December, 1942. Office of War Information, Washington, D. C.

BOOK REVIEWS

MEDICAL PARASITOLOGY, by James T. Culbertson, *Assistant Professor of Bacteriology, College of Physicians and Surgeons, Columbia University.* Cloth. Pages xii+285. 15×22.5 cm. 1942. Columbia University Press, New York, N. Y. Price $4.25.

This book deals with animal parasites of man, ranging from Protozoa to Arthropoda. It is a practical handbook prepared especially for medical students and medical practitioners. There are simple and brief descriptions of the parasites and the diseases they cause. Line drawings and numerous excellent photographs (the latter arranged on 21 plates) add greatly to the value of the book.

The author points out that the human infections caused by animal parasites are generally thought of as tropical diseases. In the past many have been largely confined to the tropics, but others have an almost world-wide distribution. The group therefore deserves more attention in temperate climates than it receives at present. Moreover, a spreading of some of the parasites to new areas will probably result from the great increase in air travel. The author concludes that our best hope of protection against them rests on more adequate diffusion of knowledge of the causative agents.

Questions of epidemiology, pathogenicity, diagnosis, specific therapy,

and prophylaxis are considered for the various parasites. An appendix contains brief descriptions of methods for studying the organisms. The general style and scope of the book make it an especially interesting and valuable reference work for the zoologist and the general biologist. The typography is excellent.

EDWARD C. COLIN
Chicago Teachers College

PLANE TRIGONOMETRY WITH APPLICATIONS (with tables), by William L. Hart, *Professor of Mathematics, University of Minnesota.* Cloth. Pages v+172+iii+124. 14.5 cm.×22.5 cm. 1942. D. C. Heath and Company, 285 Columbus Ave., Boston, Mass. $2.00.

The definitions for the general angle do not appear until after the student has had considerable experience with acute angles; this is certainly desirable for high schools. Logarithms are introduced in Chapter 2 so that the student can be expected to use them thereafter; and this, too, the reviewer considers very desirable. The author is to be commended for not hesitating to write than $90° = \infty$, and for making slight mention of the line representation of the ratios. The latter are interesting historically but of slight importance now. But after the variation of the functions has been studied there is no explanation of how we can make any use of the graphs —an item that all texts neglect.

The work on identities in Chapter 7 is very simple, and the inverse ratios are treated on a single page. The more difficult identities and equations are placed in a separate chapter, so that they can be omitted from a short course.

Besides the traditional applications there are extensive applications to problems of the war such as bombing, navigation, and the mil, all handled exceptionally well.

The student may at times be offended at being told what the reciprocal of $\frac{3}{4}$ is, and how to find the complement of an angle. These are examples, however, of how careful the author has been to explain every bit of detail and to leave nothing to chance. The pages would be more attractive if fewer different kinds of type were used on each page, and the reviewer has an aversion to "dropping" perpendiculars and "striking" arcs.

The teacher who likes a text that tells everything so that the student needs only to follow explicit directions will find this a very good text.

JOSEPH A. NYBERG
Hyde Park High School,
Chicago, Ill.

INTRODUCTION OF THE THEORY OF RELATIVITY. By Peter Gabriel Bergmann with a Foreword by Albert Einstein. Pp. 287+xvi. Figs. 8, $15\frac{1}{2}$ ×$23\frac{1}{3}$ cm. Prentice-Hall, Inc. New York, 1942. Price $4.50.

This book was written with the purpose of presenting the theory of relativity to students of physics or mathematics who had had no previous introduction to the subject, but who have a good understanding of calculus, differential equations, classical mechanics and electrodynamics. The specialized mathematical devices such as vector and tensor calculus necessary for the understanding of the general theory of relativity are developed in the book itself.

The material has been divided into three parts, under the headings, Special Theory of Relativity, The General Theory of Relativity, and The Unified Field Theories. In Part I is given an exposition of the special theory of relativity along conventional lines, and in addition, much information

that is useful to the student interested in the application of the theory of relativity to atomic and nuclear physics. In addition, ideas of invariance and covariance, the new laws of conservation are elucidated, the Compton effect is explained and the equations of motion are related to Hamilton's principle also.

In Part II the General Theory of Relativity including the work by Einstein, Infeld and Hoffman on the equations of motion are treated, and the laws of conservation for the general theory are given in detail. Part III treats of the attempts that have been made to construct a unified theory of gravitation and electromagnetism, and Weyl's invariant geometry, Kaluza's five dimentional theory and its generalizations, and finally, a summary of Einstein's and Bergmann's and Bergmann's recent work. This well-written book constitutes a valuable addition to the literature of the theory of relativity and unified field theory.

PHILIP A. CONSTANTINIDES
Wright Junior College of the
City of Chicago

LIFE SCIENCE A SOCIAL BIOLOGY, by George W. Hunter, Ph.D. *Lecturer in Methods of Education in Science, Claremont Colleges, Claremont, California. Formerly Head of the Department of Biology, De Witt Clinton High School, New York.* Cloth. 17.5 cm. ×23.5 cm. xii + 803 pages. 206 pages showing reproduced photographs and 159 pages showing drawings and tables. American Book Co., New York. 1941.

This general biology is quite comprehensively written for the secondary level. The subject matter is handled so that it bears directly on everyday life. In this book the emphasis is on the activities of the living things and their parts rather than on structure and nomenclature. Motivation is nicely provided for releasing time the teacher may use effectively in other activities of the course. Provision is made for individual differences with a series of student activities of graded difficulty. Also some units of the text are indicated which the better equipped students may attempt to handle.

The unit is made up as follows: First a full page half tone introduces the unit with few orientation questions; a preview followed by several problems. A self test appears at the end of the problems. These self tests are so designed that vocabulary difficulties are largely taken care of. Discussions questions come next with activities of various kinds and suggestions for demonstrations and laboratory exercises. Each unit ends with a self test designed to discover whether the student has gained the fundamental conceptions which the unit has tried to convey.

A. G. ZANDER

CHEMISTRY. A SURVEY COURSE FOR COLLEGES, by Gerald Wendt, Ph.D.. *Formerly Dean, School of Chemistry and Physics, The Pennsylvania State College.* Cloth. Pages v+300. 22 cm. ×14.5 cm. 1942. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. $1.75.

This book contains ten chapters that have the following titles: I—The Nature of Water; II—Atomic Structure; III—Chemical Reactions; IV—Organic Chemistry; V—Physical Chemistry: I Energy; VI—Physical Chemistry: II Contact; VII—Inorganic Chemistry; VIII—Organic Chemical Industry; IX—Biochemistry; X—The Future. There is a bibliography at the end of each chapter.

The subject material in this book deals with the principles of chemistry that are most important and play the greatest part in modern life. One does not need to have any previous knowledge of chemistry to study this book.

The author states, "It is intended for the student, whether in college or not, who will some day be a business man, a teacher, a banker, or journalist, a house wife or head of a family—in short for all citizens of a democracy in an age of science."

E. G. MARSHALL

A FIRST COURSE OF GENERAL CHEMISTRY, by Laura E. Young, *Professor of Chemistry at Mills College*, and C. W. Porter, *Professor of Chemistry at the University of California*. Cloth. Pages vii+644, 14.5 cm.×23 cm. 1941. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $3.50.

This book is an excellent text for college students who have had no preparatory course in chemistry. The fundamental principles of chemistry are explained in simple language. An elementary and interesting discussion of the electron-theory is present early.

The subject material is divided into twenty-one units and each unit is divided into parts which are closely related. Example. Unit 1, Matter and Energy, Compound, Elements and Mixtures. Part 1—The Nature of Matter. Part 2—Compounds, Element and Mixtures. Part 3—Properties of Matter and Energy, Chemical and Physical Changes. There are questions and exercises at the end of each part.

E. G. MARSHALL

NEW PRACTICAL CHEMISTRY, by Newton Henry Black and James Bryant Conant. Revised Edition. Cloth. Pages v+683. 20 cm.×14 cm. 1942. The Macmillan Co., 60 Fifth Avenue, New York, N. Y. Price $2.20.

Many features of the old edition have been retained and many new ones have been added to this revised edition. In this edition, emphasis is still placed on the fundamentals of chemistry. The authors have revised the section on atomic structure and they have given especial attention to present-day applications of chemistry to industry. A new chapter has been added to show some of the achievements of applied chemistry. In the appendix, a glossary of technical terms has been added. In this edition the authors have applied chemistry to modern life.

E. G. MARSHALL

GEOMORPHOLOGY, by O. D. von Engeln, *Professor of Geology in Cornell University*. Cloth. Pages xxii+629. 372 Maps and Illustrations. 24×17 cm. 1942. Macmillan Co. New York. $4.50.

A systematic and regional presentation of help to teachers of physical geography and an aid to instructors of aviators in the recognition of land forms.

The beginnings of many ideas concerning physiographic forms are clearly and ably presented. William Morris Davis is given full credit for the famous structure-process-stage method which is basic in physiography and for other contributions such as the peneplain, the monadnock, river terraces, etc. The gradual historical evolution of geomorphic terms is clearly presented in the text, in the illustrations and in the references which cite the basic discussion of the forms considered.

The book is a stimulation to the teacher and should be a *must* in the school library.

VILLA B. SMITH

A MATHEMATICS REFRESHER, American Edition, by A. Hooper, M. A. Cloth. Pages x+342+xiv. 14×20 cm. 1942. Henry Holt and Company, New York, N. Y. Price $1.32.

This is an American edition of a text written primarily for Royal Air Force candidates. The applications are largely to problems which would be encountered by such individuals, but the text provides ample material for any individual wishing to "brush up" his mathematics.

In many respects the book is one of the very best of its type. Some chapters are exceptionally well done, for example the chapter on graphs; the entire book seems not only one which could be studied without a teacher, but also a good text for use in a course which plans to review mathematics from arithmetic through elementary calculus. The tendency is definitely to assume or omit proofs, and concentrate on applications.

In spite of the revision, one frequently finds English usages which at times are confusing: trapezium for the American trapezoid; brackets for all types of parentheses; goods train for freight train; more use of the symbol for therefor. A few errors were noted, a very confusing double error at the top of page 183; another unfortunate answer which may well confuse the student is given to problem D15 in Chapter 2; an error in the answer to the first problem in Chapter 23.

Problems to accompany the various pages and chapters are found in the back of the book, there are over 50 pages of problems, with answers to all problems. Four place tables include logarithms and natural values and logarithms of trigonometric functions.

The typography is good, considered as a whole it would seem to be an excellent text.

CECIL B. READ
University of Wichita

ESSENTIAL MATHEMATICS, by Frank J. McMackin, *Principal, William L. Dickinson High School, Jersey City, N. J.*, and Roscoe P. Conkling, *Principal, Barringer Accredited Evening High School, Newark, N. J.* Cloth. Pages vii+372. 16.5×23.5 cm. 1943. Ginn and Company, Boston, Mass.

This text is planned for students in the first years of high school, emphasizing the practical or applied side of mathematics. Although a major portion of the material applies to everyday life, there is a considerable body of material relating to aviation. In many portions of the text one finds a distinct laboratory approach to new topics. The material is not equivalent to the tradition algebra or geometry course—study of this text might help the student decide whether he would like to continue in mathematics.

Chapters, or Topics as the authors call them, indicate the scope of the material: Measurement of lines and angles; Graphs (a rather extensive treatment of the construction and interpretation of various graphs); Areas and volumes; Formulas; Opposite quantities (positive and negative numbers); Spending money wisely (including reading meters, budgets and accounts, discounts); Using the bank's services; Protecting yourself and others (including insurance and social security); Planning sensibly for large purchases.

There is a glossary of terms used, an index, and a reasonably adequate supply of problems, without answers. The typography is excellent and there are many interesting illustrations. Objectionable features are relatively minor, for example on page 348 one might question calculating by an approximate formula interest rates to a tenth of a per cent. The figures on page 158 are entirely out of scale, in fact one might question the ability of many teachers to correctly answer the question: On Mars, how many times as high could you jump as you can jump here?

CECIL B. READ

POPULAR MATHEMATICS, THE UNDERSTANDING AND ENJOYMENT OF MATHEMATICS, by Denning Miller. Cloth. Pages xi+616. 14.5×21.5 cm. 1942. Coward-McCann, Inc., New York, N. Y.

This is one of the rapidly growing number of books which attempt to popularize mathematics, or to make the general public believe that it is possible to get mathematics without hard work. This particular text uses the historical approach, that is, most concepts are introduced with a more or less detailed treatment of the history of their development. The language of the text at times seems to "play down" to the reader, for example on page 416, "This—by Golly!—is what we want."

The material covered ranges from elementary arithmetic through integral calculus. The treatment may be extremely detailed or extremely brief; a dozen pages devoted to multiplication of negative numbers (without ever mentioning that the product of two negative numbers is positive *by definition*); half a page for fractional exponents. Some of the proofs (?) are definitely lacking in completeness, as for example that any equation of the first degree can be represented by a straight line (the proof ignores the case where the coefficient of y is zero). Again on page 415 the author ignores the fact that trigonometry uses directed line segments. Page 531 contains a definite error in the field of physics.

Many will not agree with all the historical statements, for example that Euclid's works are the foundation for mathematical method; why Gauss is given sole credit for the geometric representation of complex numbers.

The problem material consists of 25 worked examples, in a section called "Practical Mathematics." Even here one might quibble with such items as a general formula developed in problem 21, which yields absurd results if the distance is 240 rather than 24 miles. Lack of additional problem material seems a weakness, the omission of an index is even more serious.

CECIL B. READ

THE CONSERVATION OF NATURAL RESOURCES, by George T. Renner, *Teachers' College, Columbia University*. xi+228 pp. 55 figures. John Wiley and Sons, Inc. New York. Price $2.75.

This is an unusual and most useful book in its field. It is written from the point of view of one thoroughly acquainted with the material which the book embodies and the method of treatment is that of a highly skilled teacher. In contrast with the usual method of attack of authors of books on conservation, this text is concerned principally with the educational philosophy and teaching problems rather than with the technical subject-matter of conservation. However, complete bibliographies and textbook references are given together with the context of each chapter.

Part I, Facts, Ideas, and Objectives, shows the evidences of resource destruction in the United States together with methods of attacking the proposition of making our youth and other citizens resource-conservation conscious.

Part II, Outline of Resources, Problems, and Proposals, presents the major problems in our use of the various resources.

Part III, Curriculum, Methods, and Materials, classifies and evaluates the materials available to the teacher and pupil, and shows how the subject-matter may be organized for instructional purposes.

A valuable feature of the book is the Teacher's Forum in which the author presents questions and real problems for the stimulation of thought and discussion among students.

The book is suited as a text for classes in teachers' colleges and in liberal arts colleges in which courses in conservation and related subjects have

been organized. It will also prove most useful as a reference for teachers and students in the natural sciences and social sciences in colleges and secondary schools. It should be in the hands of every teacher who has anything to do with the organization of courses of study in these subjects. It will also prove interesting and stimulating to the layman who desires information on the problems of conservation in this country.

It would seem as if the appearance of books which deal thus concretely with the problem of conservation is timely if we may judge from the findings of persons who have classified the subject-matter of representative general science courses. The reader is referred to the December, 1942, number of SCHOOL SCIENCE AND MATHEMATICS, pp. 869–877. In this investigation Conservation of Natural Resources does not appear in the list of sixteen major topics reported for the schools which took part in the study. Again, in the January, 1943, issue of SCHOOL SCIENCE AND MATHEMATICS, the paper, Variation among General Science Textbooks, pp. 23–26, presents a list of fifteen topics treated in nine prominent general science textbooks showing that Conservation receives an average of 1.58% consideration in subject-matter treatment.

It is hoped that a wide circulation of this extremely valuable work will serve to stimulate constructive interest in the importance of the conservation movement.

JEROME ISENBARGER

MATHEMATICS FOR MECHANICS, by William L. Schaaf, *Professor of Education, Brooklyn College*. Cloth. Pages x+298. Garden City Publishing Co. Inc., Garden City, New York. Price $2.00.

Here, at last, is a textbook for practical shop workers which actually *teaches* mathematics. It does not give short cuts nor specific methods for solving particular problems. Instead it is an introductory treatment of the basic essentials of arithmetic, algebra, geometry and trigonometry which are needed by workmen and mechanics. The emphasis is always upon the understanding of the general methods and not their specific applications.

Some practical applications, such as vernier, gage blocks, and sine bars, are used in order to demonstrate the utility of the mathematical methods. Many of the problems are really simplifications of situations that might be met by the mechanic in his work.

This is by far the best book written for practical men because, despite the fact that none of the difficulties are overlooked, the explanations are always simple and clear. Particularly valuable is the section in graphing of formulas—a topic which most books of this type omit. Tables of square roots, logarithms and trigonometric functions are introduced and their use explained.

It is unfortunate that the publishers have seen fit to use such a poor quality paper for this worthwhile book.

BERNARD FRIEDMAN
Wilson City College
Chicago, Illinois

ESSENTIAL MATHEMATICS FOR SKILLED WORKERS, by H. M. Keal and C. J. Leonard. Cloth. Pages vi+493. 12.5×18 cm. John Wiley and Sons, Inc. N. Y. Price $1.50.

This text covers Review Arithmetic, Algebra, Geometry, fundamentals of Trigonometry, and the operation of the slide rule. Many technical facts about spur gears, screw threads, pulley speeds, and tapers are introduced into the problems.

The discussion of algebra is very clear and concise. In the geometry section the fundamental properties of triangles, circles and similar triangles are stated without proof and numerous technical applications given.

The logarithms and trigonometry section are not up to the high standard of the rest of the work. The authors use negative integer characteristics instead of the standard 9–10 notation. This complicates unnecessarily their treatment of logarithms. The relations between the angle and its complement are not explained even though the trigonometry tables make use of that fact. The functions of angles in quadrants other than the first are given a diagram but no explanation.

But overlooking these minor defects, the text, as stated in the preface, would be a useful aid in teaching "computation, with a maximum of practice and a minimum of abstract theory."

BERNARD FRIEDMAN

LOGARITHMS, TRIGONOMETRY, STATISTICS by Hollis R. Cooley, Palmer W. Graham, Frederick W. John, Arthur Tilley of the *Department of Mathematics, Washington Square College of Arts and Science, New York Unisity*. Cloth. Pages xii+280. McGraw-Hill Book Company Inc., New York. Price $2.00.

Here is an unusual textbook written for first year mathematics students interested in preparing for more advanced work. The emphasis is upon the study of the elementary transcendental functions such as the exponentials, logarithmic and trigonometric. Besides this, a considerable amount of coordinate geometry including polar coordinates and the fitting of curves to empirical functions is introduced.

The book is written as a companion volume to the same author's *College Algebra*. After covering the usual first year work in logarithms and trigonometry the author's discuss polar coordinates, polar representation of complex numbers, statistical functions and empirical functions.

The book is well written with many good illustrative examples. There are plenty of well-graded problems. Some of the other valuable features of the book are the excellent discussion of errors in numerical calculation, the graphing of sums of trigonometric functions, the applications of periodic functions to simple harmonic motion and vibrating strings.

This book can be heartily recommended to all who are looking for a textbook written from a modern viewpoint.

BERNARD FRIEDMAN

INTRODUCING INSECTS. A BOOK FOR BEGINNERS, by James G. Needham. *Emeritus Professor of Entomology in Cornell University*. Cloth. Pages v×129. 14×19.5 cm. 1943. Second Printing. The Jaques Cattell Press. Lancaster, Pennsylvania.

In this book, the author presents practical and interesting facts concerning the identification, life cycle and habits of some of the more common insects. Methods of control are given for many of the harmful species. The language is non-technical and should appeal to children as well as adults who are seeking elementary information about insect life. Many black and white drawings illustrate the text. The book should help to create a desire on the part of the reader to acquire first hand experiences with life of the insect world.

The scope of the book may be seen from the following chapter headings: Why Study Insects; How to Study Insects; Butterflies; Dragonflies; Grasshoppers and Crickets; Leaf Bugs and Leaf Hoppers; Some Common Caterpillars; Some Leaf-eating Beetles; Scale Insects and Aphids; Mosquitoes; Some Insects that Eat Our Foods; Some Insects that Eat Our Woolens;

Some Insects that Eat Fruits and Nuts; Some Carnivorous Insects; Bees, Indoors and Out; The Control of Insect Pests; How to Begin an Insect Collection; How to Rear Insects; Suggestions for the Use of This Book.

DOROTHY V. PHIPPS
Chicago Teachers College

A COLLEGE COURSE IN BUSINESS MATHEMATICS, by Henry Smithline, *Instructor in Business Mathematics, New Utrecht High School and School of Commerce, St. John's University, New York City, and* Clyde O. Thompson, *Late Associate Principal, Mount Vernon, N. Y., High School and Supervisor of Commercal Education, Mount Vernon, N. Y.* Cloth. 2×15,5 ×24 cm. Pp. xii+317. 1942. Prentice-Hall, Inc., New York. Price $1.40.

This book has been written to meet the need for a practical treatise on Business Mathematics at the college level. The book features unit-lesson organization, ample problems, drills in fundamental operations, mental arithmetic drill for every lesson, and practical teaching procedures.

JOSEPH J. URBANCEK
Chicago Teachers College

THE MATHEMATICS OF WIRELESS, by Ralph Stranger. CompletelyRevised and Enlarged. First American Eidition. Cloth. 2×14×22 cm. 1942. Chemical Publishing Company, Inc., Brooklyn, N. Y., U.S.A. Price $3.00. Pp. 1–215.

The object of the book is to enable the reader to read technical books with greater ease and facility by building a background in simple and untechnical language. The author gives lucid explanations of mathematical formulas and curves. The aim of the author is to tell something about the science of wireless so that its various branches may be better understood, thus enableing those who wish to study it further the opportunity to specialize.

JOSEPH J. URBANCEK

SPHERICAL TRIGONOMETRY WITH NAVAL AND MILITARY APPLICATIONS, by Lyman M. Kells, Ph.D., Willis F. Kern, and James R. Bland, all *Associate Professors of Mathematics at the United States Naval Academy.* First Edition. Cloth. 1.5×15×23 cm. 1942. McGraw-Hill Book Company, Inc., New York. Price $1.50. Pp. xiv+164.

The aim of this book is to meet the needs of the men who expect to become officers of the navy, army, or air corps. Besides treating spherical trigonometry in detail important applications of trigonometry and logarithms to navigation and related topics are included. Numerous pictures and solved examples run through the book giving aid and an enriched point of view as the topics progress. The emphasis is on fundamental ideas stripped of confusing details.

JOSEPH J. URBANCEK

INTERMEDIATE ALGEBRA FOR COLLEGE STUDENTS, by Thurman S. Peterson, Ph.D., *Assistant Professor of Mathematics, University of Oregon.* Cloth. 2.5×14.5×21 cm. 1942. Harper and Brothers Publishers, New York. Price $1.85. Pp. x+358.

This book is designed to serve as a text for college students who have had not more than one year of secondary school algebra. The book may serve two purposes well. It can serve as a terminal course in algebra for those preparing for the non-scientific studies and it can serve as a foundation

course or as an auxiliary for those preparing for further study in mathematics. It is well written and should prove a valuable aid to any student studying in mathematics.

JOSEPH J. URBANCEK

BLUE PRINT READING AT WORK, by William W. Rogers, Instructor in Related Technical Subjects, Edison Technical and Industrial High School, Rochester, N. Y.; and Paul L. Welton, Head, Department of Mathematics and Science, Jefferson High School, Rochester, N. Y. First Edition, pages viii+136. 77 Figures, 37 Blue Prints, Varied Photographs. 19×27 cm. Paper. List Price $1.28. Silver Burdett Co., New York. 1942.

While there are a few good books on Blue Print Reading available from a perusal of this book it is believed that there will arise a steady demand for its use. The presentation from beginning to end has a pedagogic viewpoint in mind. It should be understandable for the type of student that will need to study it. Subject matter is unified into specific teaching categories that is permeated with material of current nature. Throughout one is impressed with draftsman delineation that speaks well for the authors.

Organization of learning units is commendable, the authors having recognized the need of ample material. Relation and placement has not been overlooked, but rather has served to build upon student growth as he "climbs" from one step to the next. Photographs enhance the interest along the way while conveying methods better than words can express. Tests periodically interspersed tend to serve as a gage of student progress. Its convenient binding facilitates both the teaching and learning process.

At the beginning of the book (like Blue Print No. 1) perhaps a sheet explaining the use of circle and line in surface and edge nomenclature would make these blue prints more easily "read" for the less apt student.

LUMIR P. BRAZDA
Wilson City College, Chicago

THE SCHOOLS MUST HAVE TEACHERS

Thousands of teachers are going into other work to obtain a living wage. Thousands of sub-standard teachers are being employed. Thousands of classrooms are without teachers. The cost of living has increased over 20 per cent, but teachers' salaries have advanced less than 7 per cent. Hundreds of thousands of teachers will be forced to seek other employment unless salaries are increased. The problem is not a lack of qualified teachers; it is a lack of funds to pay living salaries.

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